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WATER POLLUTION PROBLEMS AND IMPROVEMENT NEEDS. LAKE ONTARIO AND ST. LAWRENCE RIVER BASINS

Federal Water Pollution Control Administration
Chicago, Illinois

June 1968

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LAKE ONTARIO AND ST. LAWRENCE RIVER BASINS

June 1968

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region Chicago, Illinois

and

NEW YORK STATE DEPARTMENT OF HEALTH
Division of Pure Waters
Albany, New York

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121

CONTENTS

CHAPTER PAGE

1 INTRODUCTION.................................... 2

2 DESCRIPTION OF BASIN............................ 3
  Population...................................... 3
  Economy... 3
  Water Resources................................. 6
  Water Uses...................................... 7
  Lake Currents................................... 10

3 WATER POLLUTION PROBLEMS........................ 15
  Lake Ontario.................................... 15
  Niagara River Basin............................. 18
  Genesee River Basin............................. 24
  Oswego River Basin.............................. 28
  Black-U. S. St. Lawrence River Basins........... 38
  Minor Tributary Subbasins....................... 45
  Wastes from Watercraft.......................... 51
  Oil Pollution................................... 52
  Disposal of Dredged Material.................... 53
  Pesticides...................................... 55
  Land Runoff..................................... 55
  Thermal Pollution............................... 57

4 IMPROVEMENT NEEDS............................... 61
  Water Quality Standards......................... 61
  Municipal and Industrial Waste.................. 62
  Advanced Waste Treatment........................ 103
  Nutrient Control................................ 103
  Flow Regulation................................. 103
  Combined Sewers................................. 106
  Federal Installations........................... 106
  Research and Development........................ 108

5 COSTS AND BENEFITS.............................. 110
  Cost of Waste Treatment......................... 110
  Benefits.. 113

6 CONCLUSIONS..................................... 116

7 RECOMMENDATIONS................................. 119
  Immediate Needs................................. 119
  Long-Range Needs................................ 122
  Research Needs.................................. 123

REFERENCES.. 124

FIGURES

NUMBER PAGE

1 Lake Ontario Basin.................................. 1
2 Lake Ontario Basin--Population Distribution........ 4
3 Summer (Stratified) Net Surface Circulation--Lake Ontario.................................. 14
4 Principal Zones of Water Quality Impairment--Niagara River Basin.............................. 21
5 Principal Zones of Water Quality Impairment--Genesee River Basin.............................. 25
6 Total Municipal and Industrial Wastes, Present and Projected--Genesee River Basin............... 26
7 Principal Zones of Water Quality Impairment--Oswego River Basin............................... 29
8 Total Municipal and Industrial Wastes, Present and Projected--Oswego River Basin................ 30
9 Pollution Problems in Onondaga Lake................ 31
10 Annual Phosphate Contributions to Oneida Lake...... 36
11 Principal Zones of Water Quality Impairment--Black-St. Lawrence River Basins........................ 39
12 Total Municipal and Industrial Wastes, Present and Projected--Black-U.S. St. Lawrence River Basins.. 41
13 Principal Zones of Water Quality Impairment--Minor Tributary Area.................................. 48
14 Locations of Thermal Power Plants and Industrial Cooling Water Discharges......................... 58
15 Municipal and Industrial Waste Treatment Needs--Niagara River Basin.............................. 67
16 Municipal and Industrial Waste Treatment Needs--Genesee River Basin.............................. 73
17 Municipal and Industrial Waste Treatment Needs--Oswego River Basin............................... 86
18 Municipal and Industrial Waste Treatment Needs--Black-St. Lawrence River Basins.................. 93
19 Municipal and Industrial Waste Treatment Needs--Minor Tributary Area............................ 102

TABLES

NUMBER | | PAGE

1 Present and Projected Population of the Lake Ontario Basin.................................. 3
2 Streamflow Records of the Major Tributaries to Lake Ontario and the St. Lawrence River............ 8
3 Water Quality Data - St. Lawrence River, 1955-1966... 44
4 Lake Ontario and U.S. St. Lawrence River Basins--Summary of Municipal and Industrial Waste Treatment Needs.. 63
5 Niagara River Basin--Municipal and Industrial Waste Treatment Needs.................................. 64
6 Genesee River Basin--Municipal and Industrial Waste Treatment Needs.................................. 68
7 Oswego River Basin--Municipal and Industrial Waste Treatment Needs.................................. 74
8 Black-U.S. St. Lawrence River Basins--Municipal and Industrial Waste Treatment Needs.................. 87
9 Minor Tributary Basins--Municipal and Industrial Waste Treatment Needs............................ 94
10 Low Flow Augmentation Needs in Lake Ontario Basin....105
11 Federal Installations Waste Treatment Needs..........107
12 Estimated Cost of Municipal Waste Treatment..........111
13 Estimated Cost of Industrial Waste Treatment.........112
14 Estimated Cost of Municipal and Industrial Waste Treatment for Phosphate Reduction.................113
15 Influence of Water Quality on Swimming at Public Beaches in the Lake Ontario Basin, 1965............115

PLATES

PLATE | | PAGE

1 Robert Moses State Park at Massena.................... 11
2 Sewage Treatment Plant discharge into Lake Onondaga at Syracuse.. 33
3 Debris littering southeast shore of Lake Onondaga.... 35
4 Untreated wastes from paper mills discharging into Black River.. 42
5 Webster Beach east of Rochester...................... 47
6 Waste from Hammermill Paper Company entering Lake Ontario east of Oswego, New York.................. 50
7 Badly oiled duck climbing onto ice floe.............. 54
8 Corps of Engineers dredge dumping Genesee River dredgings in Lake Ontario.......................... 56

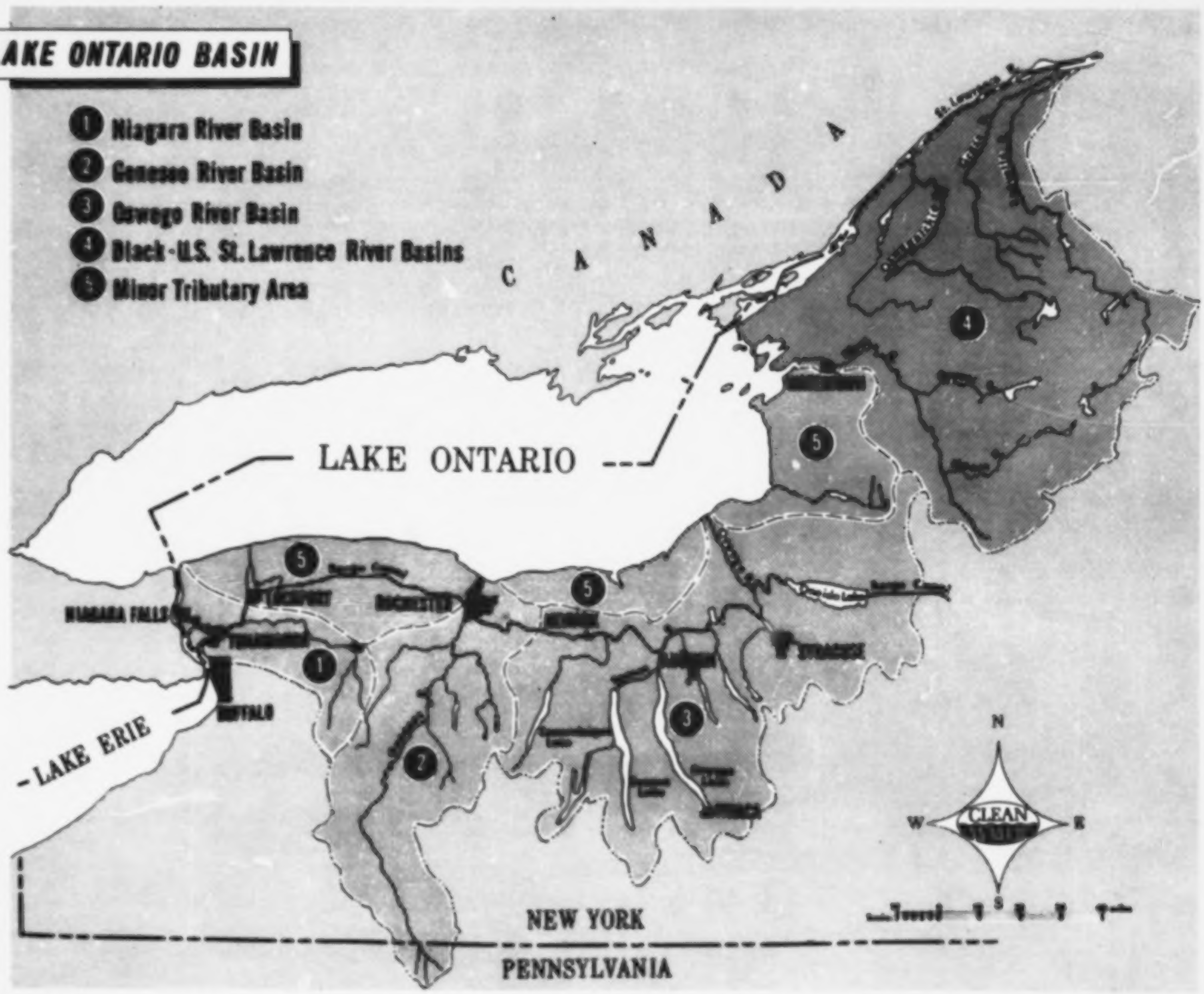

LAKE ONTARIO BASIN
① Niagara River Basin
② Genesee River Basin
③ Oswego River Basin
④ Black-U.S. St. Lawrence River Basins
⑤ Minor Tributary Area
CANADA
LAKE ONTARIO
LAKE ERIE
NIAGARA FALLS
LOCKPORT
ROCHESTER
BUFFALO
SYRACUSE
NEW YORK
PENNSYLVANIA
N
S
W
E
CLEAN
1
2
3
4
5
5
5

Figure 1

Chapter 1

INTRODUCTION

This report summarizes the water pollution problems of the United States waters of Lake Ontario and the St. Lawrence River and their tributaries. It identifies the causes of these problems or sources of pollution, discusses the improvements needed, and presents a program of recommended actions. Figure I shows the area covered.

The report is based on extensive field and office studies, initiated in 1964 and still continuing, by the Federal Water Pollution Control Administration's Rochester Program Office; and on information of the New York State Department of Health.

Additional details are available in separate reports concerning water pollution control programs for each of four principal subbasin areas. These areas are: Genesee River Basin (1)*; Oswego River Basin (2); Black-St. Lawrence River Basins (3); and Minor Tributary Basins and shoreline zones of Lake Ontario (4).

The program presented herein is the result of partnership effort between the two agencies having primary responsibility for water pollution control at Federal and State levels--the Federal Water Pollution Control Administration and the New York State Health Department. The area covered lies entirely within the State of New York, except for a small portion of the headwaters of the Genesee River in Pennsylvania. Other State, local and Federal agencies provided cooperation and support appropriate to their particular interests and responsibilities. The New York State Conservation Department, County Health Departments, and numerous cities and towns provided information and assistance. Industries extended their full cooperation in surveys of waste discharges. The Federal agencies which actively aided the study included: the Departments of Commerce (Weather Bureau), Interior (Fish and Wildlife Service, Bureau of Outdoor Recreation, and Geological Survey), Agriculture (Soil Conservation Service), and Army (Corps of Engineers).

Although the studies did not include identification of sources of wastes originating in Canadian territory, the collection of water quality data and related information was carried out in all of the main body of Lake Ontario. This reflects the long-standing amicable relations between the two nations, under which both Canadian and United States survey teams conduct scientific investigations throughout the Lake without restriction at the International boundary.

The cooperation of all who rendered assistance and information is gratefully acknowledged.

*Numbers in parentheses refer to references listed at end of report.

Chapter 2

DESCRIPTION OF BASIN

Population

Three Standard Metropolitan Statistical Areas are located largely within the Basin, centered at Buffalo, Rochester and Syracuse. Their combined population is about 79 percent of the total Basin population (Figure 2). Additional population pressure is exerted by the southeastern fringe of the Basin, thus completing what sociologists predict will some day be the initial link of the Great Lakes Megalopolitic Chain.

TABLE I

PRESENT AND PROJECTED POPULATION OF THE LAKE ONTARIO BASIN

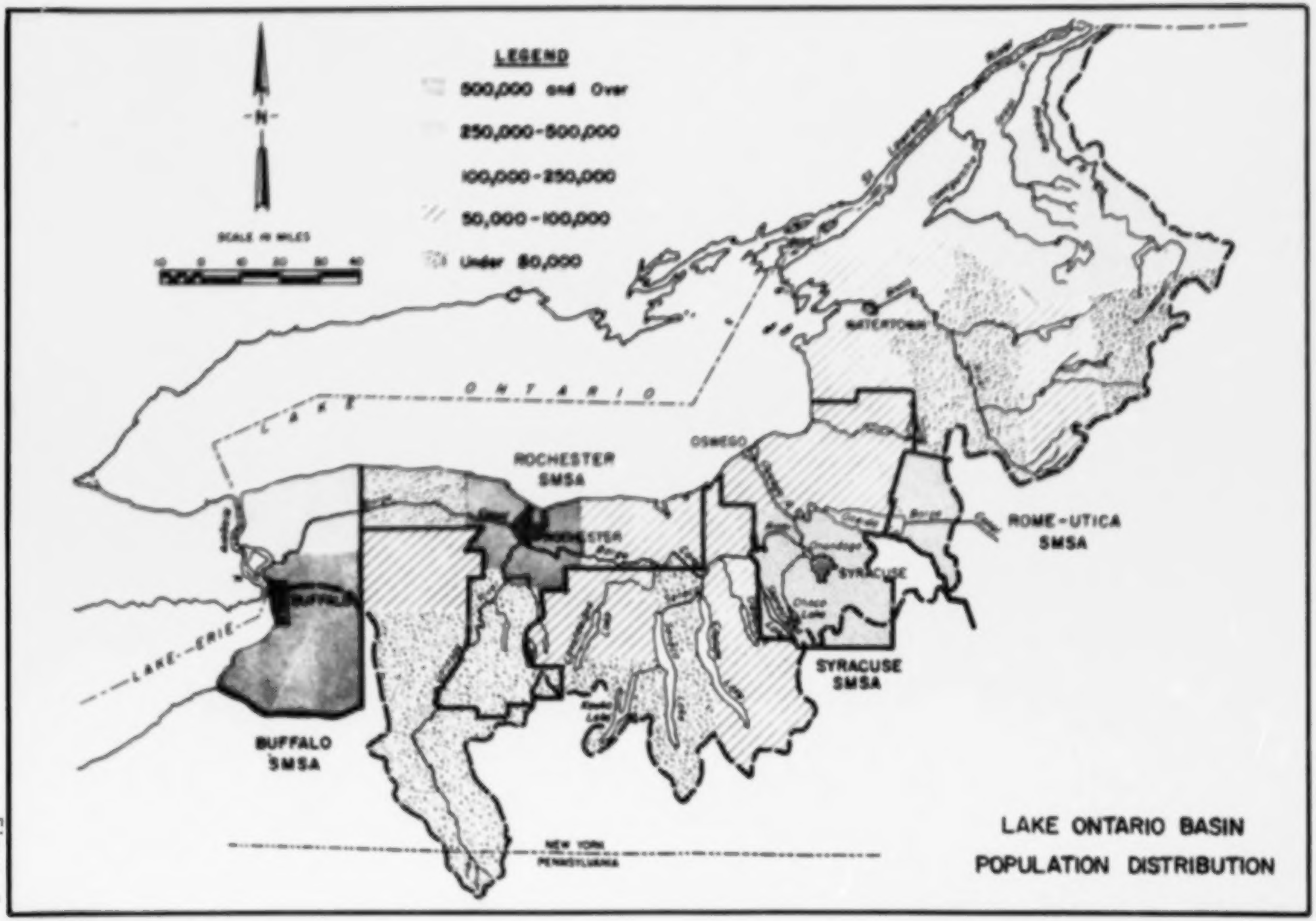
	1960	1990	2020
Total Basin Population	2,973,000	4,303,000	5,972,000
Estimated Municipal Population	2,259,000	4,472,000	5,128,000
Percent of Total Population that is Municipal	76	81	86

Note: These figures do not include the city of Buffalo.

These projections are based on an expected 45 percent increase in population by 1990, and 100 percent increase by 2020 over the 1960 population. Figures available from consulting engineering firms studying the water needs of Monroe and Onondaga counties show that the populations of these particular counties have already increased about 25 percent in the eight-year period since 1960.

Economy

Manufacturing employment is concentrated in five counties of the Basin, Erie, Niagara, Monroe, Onondaga and Oneida. Value added by manufacture in the Basin in 1963 totaled greater than 6.1 billion dollars and 85 percent of the amount was accounted for by industry in the five counties noted above. Industries within the counties of


LEGEND
500,000 and Over
250,000-500,000
100,000-250,000
50,000-100,000
Under 50,000
N
SCALE IN MILES
10 0 10 20 30 40
LAKE ONTARIO
LAKE ERIE
WATERTOWN
OSWEGO
ROCHESTER SMSA
ROCHESTER
BUFFALO
BUFFALO SMSA
SYRACUSE
SYRACUSE SMSA
ROME-UTICA SMSA
Otisco Lake
NEW YORK
PENNSYLVANIA

LAKE ONTARIO BASIN
POPULATION DISTRIBUTION

Figure 2

Monroe and Onondaga, the hubs of the Rochester and Syracuse metropolitan areas respectively, employ roughly 40 percent of the Basin's total workforce. Since 1963 there have been indications of a definite upsurge of industrial activity within the Basin. For example, unemployment figures for the past three years in the Rochester area rank among the lowest in the nation.

The more significant elements of the economy which depend upon and affect the water resources of the Basin are agriculture, manufacturing, commerce and tourism.

Agriculture

An estimated 40 percent of the land area of the Basin supports some form of agricultural production. An extensive food processing industry throughout the Basin depends on agricultural production of vegetables and fruits and poultry and dairy farming. There are over 130 food processors, largely located in the plains area along Lake Ontario and the Finger Lakes area. Processing of dairy products is the dominant activity. The total sales of agricultural products in 1959 is estimated at $335 million. There were 900,000 cattle and calves on farms in 1964. During that year approximately 235,000 tons of fertilizer were used.

Manufacturing

An integral part of the Basin economy is the papermaking industry, which is centered in the Niagara Falls, Watertown, Syracuse and St. Lawrence County areas. More than 20 mills producing pulp, paper, board and paper containers are located in these areas. Three of these mills employ more than 500 persons in each.

The chemical industry is located chiefly in the Lockport, Rochester and Syracuse areas. The largest soda ash-caustic soda plant in the world is operated by the Solvay Division of Allied Chemical on the shores of Onondaga Lake. A concentration of large chemical producers including Hooker Chemical, Olin-Mathieson, DuPont, Stauffer Chemical and Carborundum are located on the Niagara River. The Eastman Kodak Company, one of the largest producers of organic chemicals and pharmaceuticals as well as of photographic chemicals, is located in Rochester.

Production of primary metals also contributes significantly to the economy of the Basin. Three aluminum producing and processing plants employing more than 500 are located in the Massena area. Extensive mining operations, including the largest talc mines in the country, are carried on in central St. Lawrence County.

Commerce

The three United States ports of Lake Ontario handled some three million tons of cargo in 1965. Most of this cargo consisted of such bulk materials as cement, coal, salt, potash and petroleum products. The trend in commercial shipping at the lake port is for minor increases each year, with marked increase in the interlake shipments of potash to the fertilizer manufacturers in the Syracuse area.

Canal shipping has declined sharply in recent years, especially in the western sector between Syracuse and Buffalo. Shipments of petroleum products constitute the bulk of the present canal tonnage.

Tourism

The Lake Ontario Basin attracts 2.5 million vacationists annually who spend about $142 million. About 5 percent of the land area in the Basin is utilized for recreation. Of the three major recreation areas in New York State, two are in the Lake Ontario Drainage Basin, the Finger Lakes region and the Adirondack Park region. The Barge Canal, another very important recreation facility, traverses the Basin and the northern part of the Finger Lakes region.

Water Resources

The watershed tributary to Lake Ontario has a drainage area of 34,800 square miles. This includes the Lake proper, the United States portion of the watershed tributary to the Lake, including the Niagara River Watershed, and the United States portion of the St. Lawrence River Watershed. Except for a small part of the Genesee River Basin, this entire area is located in New York State. (Figure 1 is a map of the report area.)

Lake Ontario is 190 miles long and 53 miles wide. Its greatest depth is 840 feet; the average depth is 300 feet. The surface area of the Lake is 7,600 square miles, and its surface elevation is 245 feet above sea level. The volume of the Lake is estimated to be about 391 cubic miles, which is about 7.7 times the annual volume of outflow.

The natural outlet from Lake Ontario is the St. Lawrence River, whose flow at Ogdensburg, New York, has averaged 239,000 cfs during a century of record. The Niagara River is by far the largest contributing source of inflow, averaging 202,000 cfs over the long-term record. Inflows to the Lake from Lake Erie actually come by three routes: the Niagara River, the Welland Canal and the New York State Barge Canal. The water that flows through the Welland Canal is used principally for two purposes, operation of the Canal locks and hydroelectric power generation. In the recent period from 1950 to 1965, flows through the Welland Canal have averaged about 7,000 cfs (5). Flows on the order of 1,000 cfs are diverted from Lake Erie through the New York State Barge Canal System, reaching Lake Ontario by diverse routes through connected tributaries. In all, the smaller rivers and streams tributary to Lake Ontario contribute about 34,000 cfs. On an annual basis, direct precipitation in the form of rain and snowfall on Lake Ontario is approximately equal to evaporation from the Lake surface.

The vast storage volumes of the Great Lakes constitute a characteristic feature unique to the Great Lakes-St. Lawrence system. Large variations in supplies to the Lakes are absorbed and modulated to maintain flow rates in the outlet rivers which are remarkably steady in comparison with the range of flows observed in other large rivers (5). For example, flow in the St. Lawrence River, which, as previously noted, averages 239,000 cfs, has been 200,000 cfs or greater throughout 90 percent of the time in the period of record. On the high-flow side, St. Lawrence River flows have exceeded 282,000 cfs only 10 percent of the time.

Most of the major United States tributaries have steep gradients at their headwaters and decreasing slopes as they approach Lake Ontario. There are about 28,000 miles of rivers and streams in the Basin. Table 2 is a list of the most significant streams and their flow characteristics.

The Lake Ontario Basin is well endowed with natural lakes. There are 331,520 acres of inland lakes in the Basin. The most spectacular of these are the Finger Lakes, which occupy a series of nearly parallel troughs in the south central portion of the Basin.

Water Uses

Municipal Water Supply

Present total use by municipal water supply systems is approximately 300 million gallons daily and the population served by these systems is about 2 million. Lake Ontario is by far the largest source for municipal water supply with over 110 million gallons drawn daily, mostly by the cities of Rochester, Syracuse and Oswego. Syracuse is expected to double its consumption of Lake Ontario water by 1974. The Rochester area is also expected to place a larger demand on Ontario water, since its supplemental supply from Canadice and Hemlock Lakes is limited. The cities of Niagara Falls and Lockport draw over 70 MGD from the Niagara River. In addition, the Finger Lakes are extensively used for water supply. The projected basin-wide municipal water supply demand is 460 MGD in 1985 and 800 MGD in 2020.

Industrial Water Supply

The water use by industries that have private supplies is estimated to be approximately 2 billion gallons per day. Of this

TABLE 2

STREAMFLOW RECORDS OF THE MAJOR U. S. TRIBUTARIES TO LAKE ONTARIO AND THE ST. LAWRENCE RIVER

Name of Stream Gage Location	Gaged Drainage Area (sq. mi.)	7 Day 1-in-10 Low Flow (cfs)	Annual Mean Flow (cfs)	Years of Record
Black River Watertown	1,876	830	3,828	45
Moose River McKeever	365	100	811	60
Beaver River Croghan	294	205	563	35
Oswegatchie River Heuvelton	973	280	1,659	49
St. Lawrence River Ogdensburg	295,200	-	238,900	105
Grass River Pyrites	335	69	587	41
Raquette River Raymondville	1,131	470	1,898	21
Genesee River Rochester	2,467	370	2,726	44
Niagara River Buffalo	260,400	-	202,000	106
Eighteenmile Creek Burt	89	15	94	25
Clyde River Lock #25	847	90	1,030	24
Oneida River Caughdenoy	1,377	105	2,438	28
Seneca River Cayuga Lake Outlet Lock #1	3,015	52	1,537	10
Oswego River Lock #7, Oswego	5,121	900	6,200	39

total approximately 1.5 billion gallons is used by steam generating electric power utilities, 0.8 billion gallons of which is drawn from Lake Ontario. Of the remaining 0.5 billion gallons only 30 MGD is drawn from Lake Ontario. Other sources of industrial water supplies are the Niagara River (170 MGD by a variety of chemical, paper, and metals producers), Cayuga Lake (270 MGD used mostly for thermal electric generation), Seneca Lake (about 200 MGD for thermal electric generation and salt refining), Onondaga Lake (about 100 MGD by a chemicals and steel producer), the Black River (about 75 MGD by pulp and paper mills) and the St. Lawrence River (about 35 MGD by a paper mill and three aluminum processing plants).

It is anticipated that the demand for industrial water will increase about twofold by the year 2020. Much of this increase is the projected demand of nuclear power plants. Twofold growth is projected despite a much larger growth in gross industrial output, because increased efficiency and reuse of water in manufacturing processes is anticipated.

Hydroelectric Power

Eighty-eight hydroelectric plants with a capacity of over 3,600,000 KW are located on streams through the Lake Ontario Basin. About 85 percent of this total capacity, or about 3,100,000 KW, is available at the two New York Power Authority sites, one each on the Niagara River and the St. Lawrence River.

Recreation

The natural resources of the Lake Ontario Basin and the United States St. Lawrence River Basin are unexcelled for recreational use and development. The area has cool summers, beautiful inland lakes, sandy beaches, inland watercourses, glens and waterfalls, mountains and forests, making it one of the most popular outdoor recreation areas of the country. The Adirondacks Preserve, the Barge Canal System, the Finger Lakes region, and the Thousand Islands are recreational attractions of wide renown. The United States Bureau of Outdoor Recreation report "Water Oriented Outdoor Recreation - Lake Ontario" presents a thorough discussion of the facilities available, the developing problems, and the need for action to preserve and enhance this important water use. (6)

The current annual recreation demand is an estimated 35 million recreation days. By the year 2000 this amount should more than triple and by 2020 a fivefold increase can be anticipated. There are more than one-third of a million acres of water and land available for outdoor recreation at over 358 areas in the Basin. About 80 percent of these areas have water-dependent facilities.

The Finger Lakes region is the most widely used recreation region in the Basin, followed by the area along the Lake Ontario shoreline. There are 130 public and private recreation areas totaling 121,000 acres in this region. There were 2.5 million visitors to the Finger Lakes region in 1965. The Finger Lakes offer good fishing for lake trout, rainbow trout, pike, walleye, black bass and pan fish. Naples Creek, a small tributary to Canandaigua Lake, is crowded elbow to elbow in the spring for the rainbow spawning run. Two thousand fishermen have been seen fishing on the lower 2 to 3 miles of this stream at one time. Boating is extremely popular on these lakes especially Cayuga and Seneca which are linked to the Barge Canal.

The Lake Ontario shoreline, which is second in recreation demand and will probably serve a large role in the future development of recreation facilities in the Basin, has fourteen public beaches located rather uniformly along 150 miles of United States shoreline. The best sand beaches are located on the eastern end of the Lake around Mexico Bay. Numerous bays and coves provide excellent areas for small boat harbors, fishing and water skiing.

The St. Lawrence region also is a popular recreation attraction. Robert Moses State Park had 185,000 visitors in 1965. The St. Lawrence River, especially in the Thousand Islands area, is famous for its muskelunge and northern pike fishing. The Adirondack Forest Preserve encompasses about two-thirds of the Black-United States St. Lawrence River Basin and boasts hundreds of lakes and mountain streams. Fishing, hunting, and hiking are most popular here. (Plate I)

The State Barge Canal System is another of the Basin's valuable recreational assets. Over 100 small boat marinas are established along the canal system. Pleasure boating has more than quadrupled in the last fifteen years, as indicated by the number of permits issued for lockage. The State Department of Public Works reported issuing 2,000 such permits in 1952 and over 10,000 in 1965. An estimated additional 30,000 craft use the canal system between the locks.

Lake Currents

Waterborne wastes reaching Lake Ontario are dispersed into the main water mass by three means: molecular diffusion, turbulent mixing, and lake currents. Considering the Lake as a whole, currents are the predominant mechanism for the movement and subsequent dispersion of these wastes into the Lake's water mass.

Four principal factors govern currents in Lake Ontario: winds, water temperature, barometric pressure, and inflow from the Niagara River. Of these four, the dominant factor is usually the speed and direction of the wind.

PLATE NO. 1 - Robert Moses State Park at Massena.

In the summer, Lake Ontario water becomes divided into an upper layer of warm readily circulating water called the epilimnion and a lower layer of cold and relatively undisturbed water called the hypolimnion. The layer separating the epilimnion and hypolimnion, a region of rapid temperature change, is called the thermocline. When the Lake is thus stratified, the waters in the hypolimnion are physically and chemically isolated. As a result little oxygen replacement takes place in this zone during this period and any chemical or biological system must operate on a reserve supply. Fortunately in the case of Lake Ontario, 85 percent of the Lake's volume is in the hypolimnion, providing a large reserve. This is not the case in shallow water lakes, such as Lake Erie, where less than 20 percent of the total volume is contained in the hypolimnion and serious oxygen depletion of the hypolimnion is common.

During the summer stratification, the volume of water with which a pollutant could mix is greatly reduced. What might be considered a safe input in the winter months when the Lake is essentially isothermal may in summer months be critical to water quality, particularly in embayments during periods of quiescence.

In the winter months the Lake again becomes stratified; stratification is not so stable nor so pronounced as in summer and for practical purposes the Lake can be considered to be essentially isothermal.

The thermocline begins to develop in late May, reaching its maximum development and depth of approximately 70 feet by August. From September the epilimnion begins to cool until the stratification becomes unstable and overturn occurs, usually in conjunction with a storm. This fall overturn can occur as early as late October. However, it usually occurs some time in November. A point to remember here is that while the Lake is cooling and the temperature of the epilimnion becomes less, the depth to the thermocline tends to become greater because of increased mixing.

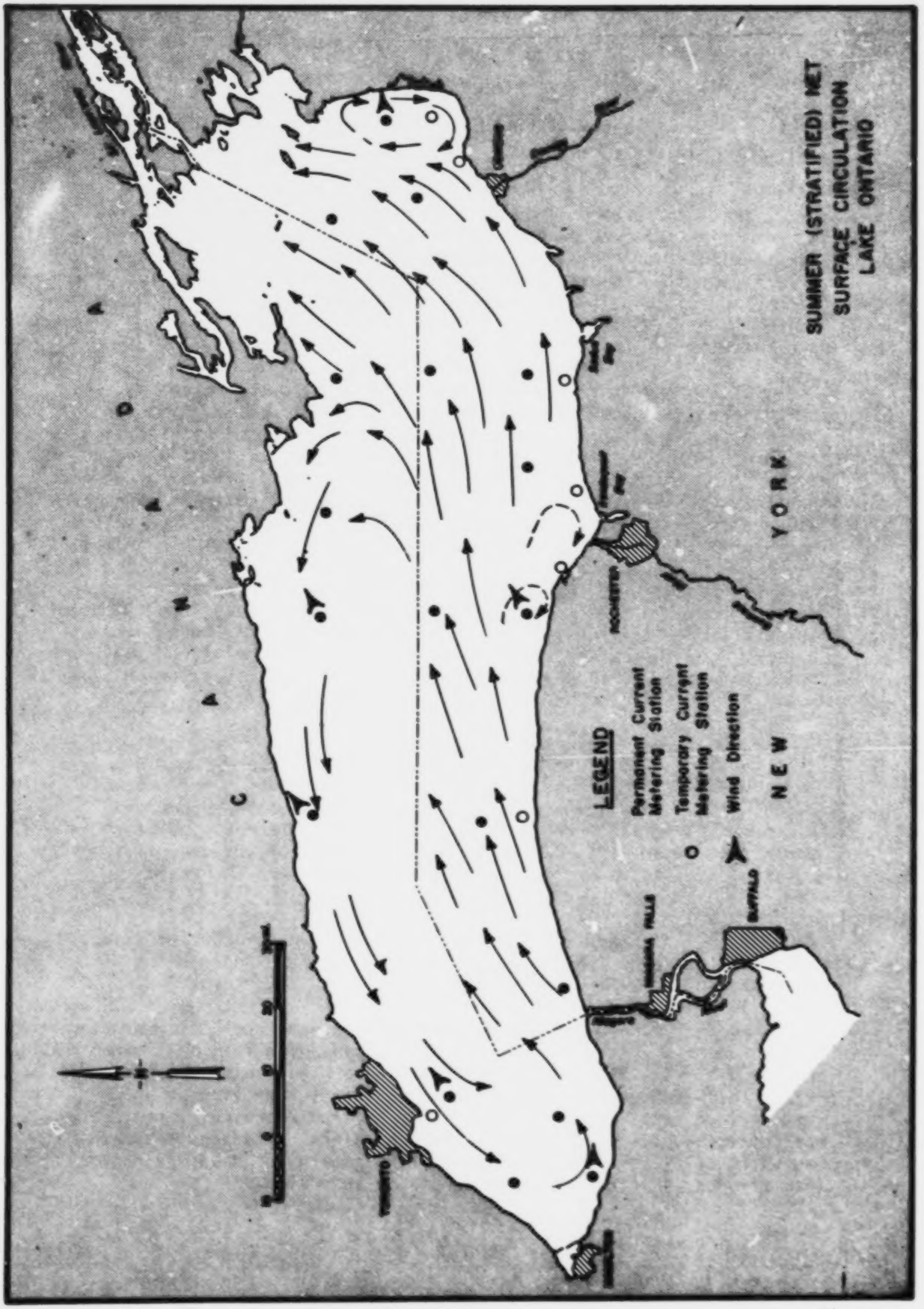
In early spring and sometimes in the fall, when the main body of lake water is essentially isothermal, a horizontal stratification occurs along the shoreline. In the spring, the water of the rivers entering the Lake is warmer than the Lake water. This, in conjunction with more rapid heating of the inshore waters, causes a strong density interface, the "thermal bar," to develop at the 4°C isotherm or temperature of maximum density. Development of the thermal bar begins in local embayments and areas of stream inflow. At times, depending on wind conditions, the thermal bar may encircle the Lake, separating the main body of the Lake water from inshore waters. In the fall the thermal bar is not as extensive or as well developed as the one that occurs in the spring. Pollutants discharged into the inshore side of the thermal bar can buildup to high levels. For example in the Rochester area during the spring several water intakes, sanitary outfalls discharging poorly treated waste, and the polluted Genesee River outflows are at times restricted to the same limited water mass. The thermal bar phenomenon is also a mechanism whereby enriched waters may be held in the inshore growing area at the beginning of the growing season, when nutrient demands by the biota are highest.

The surface waters of Lake Ontario respond very rapidly to a change in wind stress. A current change less than six hours after a wind shift is common in mid-lake. In the inshore area the response is even more rapid. The net circulation, which on a long-term basis can be considered the circulation pattern of the Lake, actually exists for only short periods of time. One week would be considered a long time for the net circulation pattern to be operating. Whenever the net circulation pattern is not operating, the circulation of the Lake is principally dependent on the winds; hence a variety of patterns can develop, some of whose relation to winds are not readily apparent.

Two distinct seasonal surface circulations occur in Lake Ontario. When the water mass is stratified, the net surface flow (Figure 3) including the Niagara River discharge is strong toward the east along the southern shore. The waters of the epilimnion are well mixed during this period. Generally the Niagara River water is completely dispersed by the time it reaches Rochester. However, under some conditions of flow the Niagara River water will hold tightly inshore for a much longer period of time. This is particularly true if a major thermal bar has developed. Also, the Niagara River flow will at times be directed toward the Hamilton-Toronto area. A return flow to the west originates east of Scotch Bonnet Shoal.

In the eastern end of the Lake, flows are generally toward the northeast and are less sharply defined than in the western end of the Lake. Major eddies tend to develop in the area of Mexico Bay, Scotch Bonnet Shoal and Rochester. There is a suggestion of a particularly large eddy developing at times in the western end of the Lake. If this eddy occurs as suspected, retention times for pollutants would be longer and some buildup could occur.

In the fall, usually November, the Lake becomes isothermal and the whole water mass is influenced by the winds. Also, the direction of the prevailing winds shifts and increases in speed so that the winds are now principally from the west-northwest. As a result, the whole net surface flow is eastward and a bottom return flow is developed westward. During this period of net circulation the water of Lake Ontario is completely mixed from surface to bottom. The major net flow is still, however, along the southern shore as it is in summer.



SUMMER (STRATIFIED) NET SURFACE CIRCULATION LAKE ONTARIO

LEGEND
Permanent Current Metering Station
Temporary Current Metering Station
Wind Direction
CANADA
NEW YORK
TORONTO
NIAGARA FALLS
BUFFALO
ROCHESTER

Figure 3

Chapter 3

WATER POLLUTION PROBLEMS

The first part of this chapter summarizes the major problems in each of six geographic subdivisions of the study area, starting with Lake Ontario itself. The last part of the chapter discusses certain general problems which by their nature are more readily categorized by type than by area of occurrence.

Lake Ontario

Every lake undergoes a biological aging process which leads--in time measured on a geologic scale--to its destruction. This process, called eutrophication, is characterized by a buildup of nutrients in the lake environment. A biologically healthy lake contains a myriad of living organisms, ranging from elemental one-cell life forms upward through successively more complex forms to fish. A balanced aquatic life system can be visualized as a pyramid, in which each successive level forms a link in the food chain that sustains the higher levels. At the base of this pyramid are one-celled plants called algae, which are microscopic in individual size but visible when clustered in colonies. Algae and other elemental organisms are capable, through photosynthesis, of utilizing inorganic (non-living) elements in support of growth. Many inorganic elements are required for algal cell growth, including nitrogen, phosphorus, potassium, calcium, and iron--as well as certain organic substances, required in minute quantities. (7)

Lake Ontario, as well as other Great Lakes and many smaller lakes in the Basin, is being oversupplied with nutrients, and hence the naturally slow process of eutrophication has been greatly accelerated. Apart from the natural background supply, the source of this oversupply of nutrients can be traced to the activities of man. Nutritional material, especially phosphorus (one of the essential growth elements), comes from agricultural runoff and the wastewaters of cities and industries.

Over-enrichment of the Lake has led to over-production of algae, upsetting the natural balance in the food chain and interfering with many water uses.

Probably the major and most perplexing water pollution problem in Lake Ontario is the yearly crop of *Cladophora*, a form of filamentous green algae. In suitable environments these plants attach to any firm object in the water and grow, by cell division, into strings which will vary in length, from a fraction of an inch where nutrients are scarce, to several feet in nutrient-rich waters. *Cladophora* growth begins in early spring with a fringe-like growth and develops rapidly into strands 15 inches or so in length by late June.

These strands break away from their attachment surfaces, drift up onto the shore, decompose, and cause strong odors and unsightly conditions. During the early summer months it is a common occurrence at beaches to see no swimmers in the water and lifeguards raking and shoveling *Cladophora* onto trucks.

Prolific growths of *Cladophora* have been reported in Lake Ontario as far back as 1932. (8) Their distribution appears to be governed by water movements, growth being more abundant where currents keep the supply of nutrients replenished. Light penetration governs the depths to which *Cladophora* (and other algae) grow; growth occurs in Lake Ontario from the surface to depths of 30 feet and more.

The largest single source by far of nutrient inputs to Lake Ontario is the Niagara River--reflecting the fact that this Lake, being downstream from the other four Great Lakes, suffers the consequences of what happens above it in the Basin. Fortunately for the health of Lake Ontario, a major part of the nutrients known to be going into upstream Lake Erie is retained in that Lake and not carried out by the Niagara River. Nevertheless, the threat of eutrophication in Lake Ontario makes more urgent the need for action now getting underway to reduce the nutrient inputs upstream from it.

Lake Ontario has not thus far exhibited one of the symptoms of advanced eutrophication found in Lake Erie, that of severe oxygen depletion in its deep waters. This phenomenon in Lake Erie is attributed to an indirect effect of over-production of planktonic algae, i.e., algae that grow freely suspended in the water, not attached to bottom surfaces. As these colonies of algae flourish, die, and slowly settle to the bottom, their decomposition exerts a demand on the dissolved oxygen resources in the water. The drain on oxygen reserves is most severe in the hypolimnion during periods of stratification in which replenishment of oxygen from upper waters, and from the air above the Lake, is inhibited. Lake Ontario differs from Lake Erie in two important respects: 1) the observed growth of planktonic algae in open waters of the Lake has not been as intense, and 2) Lake Ontario's greater depth makes the volume of water in the hypolimnion much greater than it is in Lake Erie. As a result, the lowest value of dissolved oxygen observed in the hypolimnion of Lake Ontario in lakewide surveys was about 70 percent of saturation. While this is not, as yet, a serious depletion it is another subtle warning sign of advancing eutrophication.

Another dramatic example of an upset in the balance of nature is the invasion of the Great Lakes by the alewife. These little fish, descendants of a species which has migrated into the Lakes from the ocean and adapted itself to the fresh-water environment, have become pests mindful of the great locust plagues recorded in history in some land areas of the world. The Great Lakes alewife is a useless fish.

They are not good to eat, and there is no sport to catching them. Efforts to find a commercial market for them, as animal food, have been only partially successful. By competing for food supply, they crowd out other and more desirable species. Worst of all, they die in enormous numbers within a short period during each summer and the dead fish drift onto the shores, adding their stench to the windrows of rotting *Cladophora* on beaches.

Ontario was the first of the Great Lakes to be invaded by the alewife, and the massive die-off has become an annual event in the Lake. There is no evidence that water pollution contributes to their deaths, but the dead alewives are themselves a form of water pollution because of obvious interference with water uses. The Interior Department's Bureau of Commercial Fisheries is spearheading the search for further answers to the alewife problem, including ways to bring the alewife population into balance with other aquatic life.

In addition to the buildup in nutritional compounds, Lake Ontario waters have deteriorated in chemical quality, measured by such parameters as the sulfate and chloride ions and total dissolved solids. Data collected at selected points around the Lake such as water intakes show that chemical quality was changing very gradually during the half-century prior to about 1910. Indicative of sharp increase in chemical constituents since that time, sulfate concentration has gone from 15 to 30 parts per million (ppm) and chloride from 7 to 26 ppm. As previously noted, the chemical quality of Lake Ontario water is determined mainly by the quality of water coming down to it from the upstream watershed. In particular, the chloride increase has been attributed to a parallel buildup in Lake Erie, and this in turn to the growth of salt mining and related chemical industries on the watershed, concentrated mainly in two areas, the Detroit-Windsor area at the western end of Lake Erie, and northeastern Ohio. (9)

As the concentration of a persistent substance, such as the chloride ion, builds up in a lake, so does the quantity removed by transport in the outflowing water. This points up a significant difference between a lake which has an outlet, such as the St. Lawrence River flowing out of Lake Ontario, and one like the Great Salt Lake which has no outlet, inflowing water being removed from the lake by evaporation. The outlet has a natural arresting effect upon buildup of chemicals within the Lake. Although the threefold increase in chloride in Lake Ontario has quite understandably caused concern, the present level of concentration is well below that which would cause significant impairment to water uses. Nor does there appear to be cause for concern about future increases, but this is not to be construed as condoning the dumping of chloride or any other substance into these waters where reasonable steps can be taken to exclude it.

Niagara River Basin

The Niagara Drainage Basin with the world renowned Niagara Falls separates Lakes Erie and Ontario. Some 1.3 million people live in the United States portion of the Metropolitan Buffalo-Niagara area and the area contiguous to the Basin. The sewage from these people finds its way into the Niagara River although only a portion of the 1.3 million people actually live in the Niagara River Basin. The metropolitan area is highly industrialized and supports the major source of electrical power for the eastern Great Lakes. Less than 10 percent of the contributing area is considered to be rural.

The Niagara River has an average flow of about 202,000 cfs. For all practical purposes all of the flow comes from Lake Erie. Minimal flows from the Buffalo River and Tonawanda Creek have little effect on volume of the Niagara River. The Tonawanda Creek effect is reduced to nil when the Barge Canal is in operation. At that time Niagara River and Tonawanda Creek water, up to 1,300 cfs, flow east through the canal.

Buffalo River

The Buffalo River, while not in the Niagara River Basin, does have considerable effect on the water quality of the Niagara River. Low flow in the Buffalo River itself creates about a 70-day detention time in the lower River. The industrial reuse of this water concentrates the waste. In 1967 industry constructed its own pipeline to Lake Erie. The once used water is now discharged directly to the Buffalo River to provide a minimum flow of 100 MGD. Periodic flushes of the river water cause slugs of highly concentrated industrial waste and oil to be discharged to the Niagara River. These flushes have serious temporary detrimental effects on the Niagara River. High phenols give taste to drinking water, oil and dyes cause esthetic problems, and sewage causes high bacterial counts. At times the dissolved oxygen in the Buffalo River is depressed to zero. Another factor that indicates the condition of the Buffalo River and its effect on the Niagara River is the total absence of biological organisms in the lower Buffalo River. Although no fish kills have been experienced in the river since 1951, the shock load of the Buffalo River "slugs of waste" on the Niagara River must make immediate local demands on the Niagara River dissolved oxygen.

Tonawanda Creek

Tonawanda Creek is about 101 miles long, has an average flow of about 390 cfs and has 31 tributaries in its drainage basin. In comparison to the 202,000 cfs flow of the Niagara River the creek exerts little pollution pressure on the river. However, when the Barge Canal is open, the creek could have a marked effect on the quality of the canal waters.

The upper reach of the creek above the Barge Canal with a few exceptions has relatively good water. Waste from Attica Prison, sewage from Attica, toxic waste from the National Lead Company at Batavia, enrichment from the well operated Batavia Sewage Treatment Plant, and sewage from Akron on Murder Creek caused polluted conditions for short distances below the noted outfalls. The creek recovers sufficiently, however, to be in good condition by the time it reaches the canal.

Near its mouth Tonawanda Creek is joined by Ellicott Creek, a highly enriched stream. The enrichment is caused by sewage from Alden and the Erie County Home and Penitentiary, septic tank discharges, and sewage from Amherst. The enrichment causes algal growth and dissolved oxygen depletion in the creek as it passes through Ellicott Creek Park, and is carried into Tonawanda Creek and the Niagara River.

Minor Streams

Scajaquada Creek watershed between the Buffalo River and Tonawanda Creek is degraded to a variable degree throughout its length. The effluent from the Westinghouse Manufacturing Plant in Cheektowaga is essentially the flow in the creek except in wet weather. The entire flow of the stream enters a Buffalo Sewer Authority intercepting sewer for eventual primary treatment except in wet weather, when flows in excess of 700 cfs are bypassed. Normal flow in the creek is about 28 cfs.

Storm water overflow from the City of Buffalo, the bypassed wet weather flow and industrial waste are augmented by Buffalo City water (in the summer) to make up the flow in lower Scajaquada Creek. Even with the city water the lower stream remains grossly polluted, with periodic oil films. It discharges directly to the Niagara River.

Another small creek, Two Mile Creek, also receives storm and sanitary waste which make stream conditions objectionable. While a good portion of the creek is in conduit below ground, an open section of this polluted stream runs through a park and golf course.

Gill Creek is above the Falls and traverses part of the City of Niagara Falls. DuPont Company and Olin-Mathieson Company discharge waste to the stream; DuPont discharges 32 MGD, or 95 percent of the dry weather flow in the creek. The outflow from Gill Creek contributes considerable quantities of dissolved solids, chlorides, and wastes high in chemical oxygen demand (COD).

Cayuga Creek in Niagara County is a small stream that drains an area north of Niagara Falls. The main source of pollution is a flow of 80,000 gallons per day from the Niagara Municipal Air Base Group, a federal installation. Partially treated sewage from the base, the City of Niagara Falls and the area outside Niagara Falls, cause dissolved oxygen depletion, algae growths and disagreeable odors in the lower portion of the creek.

Niagara River

The nutrient-laden waters of Lake Erie, wastes from the heavy industrial complex along the Buffalo River, and direct waste discharges from municipalities and industries constitute the major pollution load to the Niagara River.

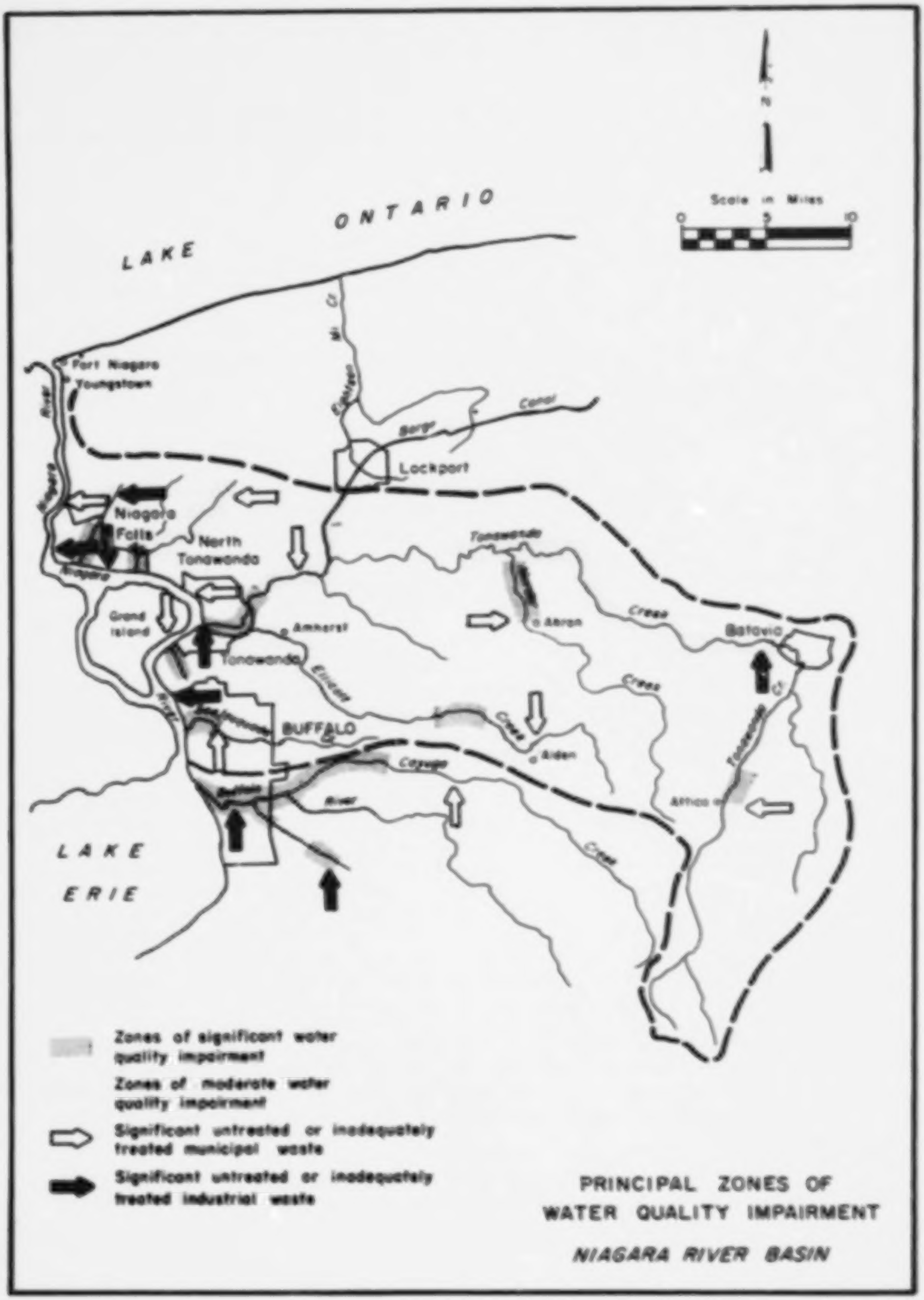
Because of the large volume of Lake Erie water in the river, the effect of most of the pollutants in the discharged wastes is masked by the tremendous dilution ratio. However, certain indicators of pollution such as phenols, oil and coliform bacteria are still evident. (See Figure 4.)

Excessive growths of *Cladophora* in the Niagara River, along with algae from Lake Erie and the upper Niagara River tributaries, form large accumulations below the Falls. The decay of large masses of these plants in the area of the Maid of the Mist docks on the Canadian shore contributes to the obnoxious odor problem being experienced in the lower Niagara River.

The Buffalo River pollution tends to hug the east bank of the Niagara River for about six miles before mixing throughout the river. The polluted portion of the river also receives waste from the Buffalo Sewer Authority and Scajaquada Creek, respectively 3 and 4 miles downstream of the Buffalo River. The Buffalo Sewer Authority discharges about 143 MGD of primary treated waste to the river.

Phenols found in the upper six miles of the Niagara River are associated with the waste discharges from the Mobil Oil Refinery (reportedly planning to discontinue refinery operation in 1968), Donner-Hanna Coke Plant, and the Buffalo Dye Plants on the Buffalo River. Other industries and the municipal sewage treatment plants discharging oil from facilities on the upper river also add to the potential phenol taste and odor problem. These sources of phenols, along with several waste sources above the falls, are a potential cause of taste and odor problems at municipal water supply intakes on the river. On one occasion in 1967 phenols of 28 micrograms per liter were found at the confluence of the Niagara River and Lake Erie. Although no known phenol problems have been reported on the Upper Niagara River in the past few years, it should be noted that it is routine practice by the Canadians to treat for taste and odors due to phenols at Niagara-on-the-Lake, located near the mouth of the River.

The Buffalo River adds an unpleasant dark color to the Niagara River. The discoloration in the Buffalo River is caused by a mixture


N
Scale in Miles
0
5
10
LAKE ONTARIO
Fort Niagara
Youngstown
Niagara River
Eighteen Mi. Cr.
Barge
Canal
Lockport
Niagara Falls
North Tonawanda
Niagara
Grand Island
Tonawanda
Amherst
Tonawanda
Akron
Creek
Batavia
Ellicott
Creek
Tonawanda Cr.
BUFFALO
Cr.
Creek
Alden
Cayuga
River
Buffalo
Creek
Attica
LAKE ERIE
Zones of significant water quality impairment
Zones of moderate water quality impairment
Significant untreated or inadequately treated municipal waste
Significant untreated or inadequately treated industrial waste

PRINCIPAL ZONES OF
WATER QUALITY IMPAIRMENT

NIAGARA RIVER BASIN

Figure 4

of oils, dyes, and other industrial wastes, municipal waste, and septic conditions in the lower river. Allied Chemical-Buffalo Dye, Republic Steel and Symington Wayne all contribute color to the Buffalo River. National Lead at Batavia on Tonawanda Creek causes a local color problem, which disappears a short distance downstream.

Contributions of waste from the Buffalo River through storm and combined sewer overflows and septic tank and sewage treatment plant effluents affect the coliform levels on the east shore of the Niagara River. The Buffalo Sewer Authority effluent and combined sewer overflow also add to the coliform count in the river. In 1967 samples collected by the International Joint Commission (IJC) near the east shore indicated median coliform counts to be 6700/100 ml and 3600/100 ml about 2 and 4 miles respectively downstream of the Buffalo River. Midstream samples at these mile points strongly reflect Lake Erie water and are consistently low. These are median counts and do not reflect the maximum levels, and they are sufficiently high to demonstrate the hazard of swimming in the Grand Island area, and to point out the vigilance required by waterworks operators to guard against contaminated water.

The reach of the Niagara River from south of Grand Island to the falls receives about 50 percent of the industrial waste and 10 percent of the sewage in the Basin. About 175 MGD of industrial waste is discharged directly to the Niagara River or Tonawanda Creek. The industrial wastes are quite varied, containing oil, solids, phenols, color, toxic metals, acids and alkalies, and exerting high biochemical and chemical oxygen demands. Seven sewage plants in this sector discharge about 30 MGD of primary treated waste.

In viewing this sector of the river it is significant that waste discharged to the lower reaches of Ellicott or Tonawanda Creeks or to the Niagara River upstream of Tonawanda Creek is transported up Tonawanda Creek to the Barge Canal when the Canal is in operation. In view of the subsequent uses of canal water, the waters directed to the canal should be of good quality.

Oil discharged by Ashland Oil and Refinery Company also tends to hug the east shore of the Niagara River for several miles downstream. When the oil does not flow into Tonawanda Creek it flows to the lower Niagara River, and accumulates to the detriment of wildlife.

Some 36 MGD of waste containing phenols are discharged to this section of the Niagara River. Allied Chemical - Semet Solvay and Ashland Oil Company at the 29 mile point contribute 33 MGD to the river. The phenols are carried down the river along the United States shore for about three miles before they are dispersed.

Discharge from the Hooker Chemical - Durez Plastics Company at the 24.6 mile point is one-tenth of Allied Chemical and Ashland Oil

Company discharge, but more potent. In 1961 Hooker Chemical was known to discharge some 1,000 pounds per day of phenols to the river. In recent years phenol concentrations up to 200 micrograms per liter and averaging 100 micrograms per liter have been found below Hooker Chemical's discharge. Some of these phenols enter the New York Power Authority intake at mile point 18.0 and subsequently enter the lower Niagara River at the power plant discharge at mile point 9.0, thus bypassing the falls and adding some residue to the lower Niagara River. Recent data also indicates that at times phenol from the Hooker Chemical - Durez Plastic Company does reach the mouth of the Niagara in the vicinity of the municipal water plant intake of the town of Niagara-on-the-Lake in Canada.

Color in the reach of the river between the south end of Grand Island and the Falls is mainly caused by four industries. Spaulding Fiber, Continental Can and International Paper discharge about 16 MGD of varicolored paper waste to the Niagara River in the vicinity of Tonawanda Creek. The color is carried downstream a very short distance before being dispersed. Union Carbide, located at the 18 mile point downstream of the New York Power intake, discharges about 21 MGD of waste to the river. Some 5,000 pounds per day of calcium are discharged about 400 feet off the United States shore. The waste creates a plume 100 feet wide and is carried downstream for about two miles. The color then disappears from view in the turbulent waters above the falls. The calcium forms an insoluble carbonate in the river.

The IJC study (10) of the river shows a buildup of coliform from 3600/100 ml at the 34.3 mile point to 6800/100 ml at the 23.6 mile point just below the North Tonawanda primary sewage treatment plant. Sewage from septic tanks illegally connected to storm sewers and sanitary sewer overflows in Cayuga Creek (Niagara County) area have caused coliform counts to rise sharply to 20,000/100 ml at the 20 mile point. The increase from 3600 to 6800 per 100 ml takes place in the area of the water supply intakes for Lockport, North Tonawanda and Tonawanda. The 20,000 per 100 ml count at the Niagara River and Cayuga Creek confluence, while not a distinct threat to the City of Niagara Falls and Niagara County Water Authority intakes across the river, is a definite threat to the Niagara Falls emergency intake two miles downstream.

The Niagara River immediately below the Falls acts as a collection basin for a good part of the upstream waste. The mechanics of river flow tend to concentrate floating material at various locations along the lower river. While the largest share of waste load to the river comes from above the falls, the lower river is not without its own waste sources. The City of Niagara Falls discharges 71 MGD of sewage to the lower river, with virtually no treatment except screening. Few industries discharge waste directly to the river but a diversion sewer around the falls does carry about 30 MGD from a number of industries just above the falls. The wastes from these industries contain color, solids, oil, and acid. Another product of the diversion sewer is obnoxious odors that fill the lower river in the vicinity of the falls.

The industries on the diversion sewer include a considerable amount of cooling water in the approximately 30 MGD of waste they discharge. Oil and phenols are present in limited amounts. The lower river has a tendency to release floating oil films. These films are dangerous and often deadly to waterfowl. Phenols also build up in the lower river. This buildup causes problems of taste and odor for Niagara-on-the-Lake water supply. (10)

Color is a definite problem on the lower river. The diversion sewer discharges near the falls and in full view of the Rainbow Bridge and the New York State Observation Tower. The color and floating scum detract from the beauty of the falls. Perhaps the most significant reminder of the plight of the falls and a constant irritant to local residents and the millions of people who visit the area is the obnoxious odor from the diversion sewer and from decaying algae.

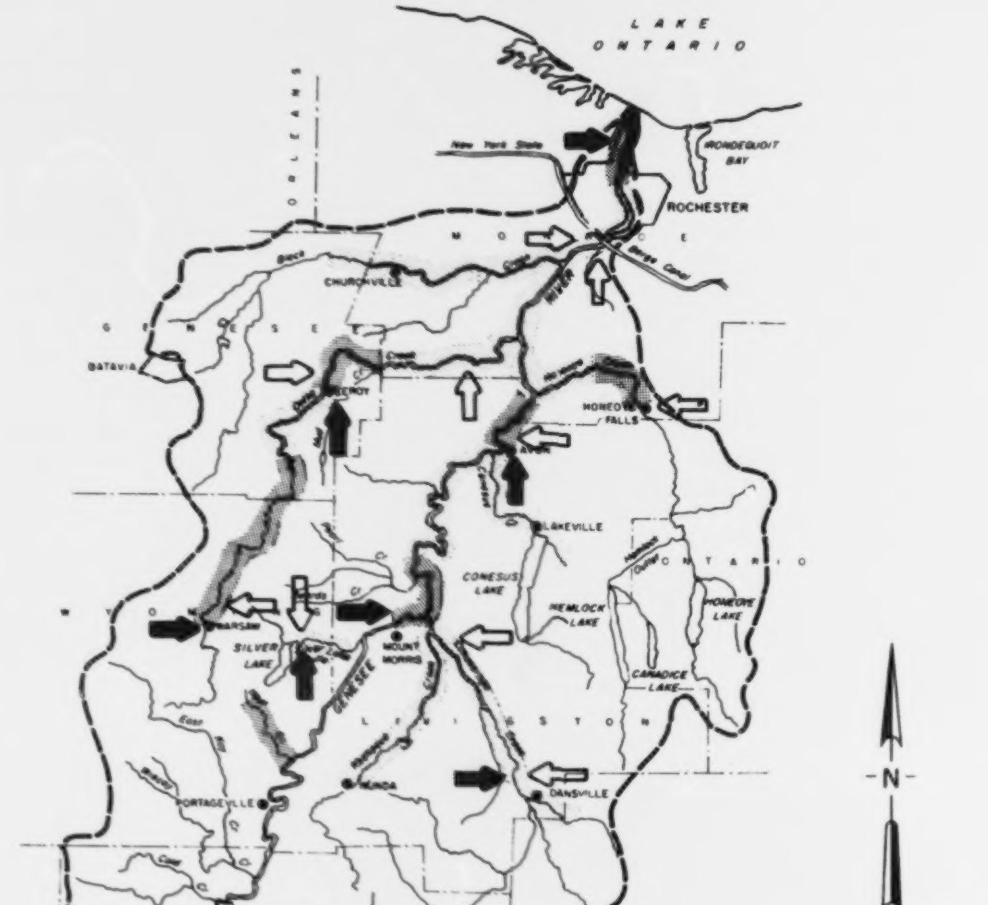
In summary, pollution of the waters of the Niagara area constitutes a health hazard, creates problems in control of taste and odor in municipal water supplies, periodically destroys waterfowl, and detracts from the esthetic values of one of the world's most famous scenic attractions. This pollution is the more regrettable because it is so needless; with reasonable attention to the treatment of wastes from cities and industry, the tremendous flow of the Niagara River is capable of assimilating treated wastewaters without perceptible effects.

Genesee River Basin

The major areas of water quality impairments in the Genesee River Basin are shown in Figure 5. Sectors on the lower and central part of the main stem and on Honeoye, Keshequa, Wolf, Oatka, Black, Wilkins, Conesus and Canaseraga Creeks are the most serious.

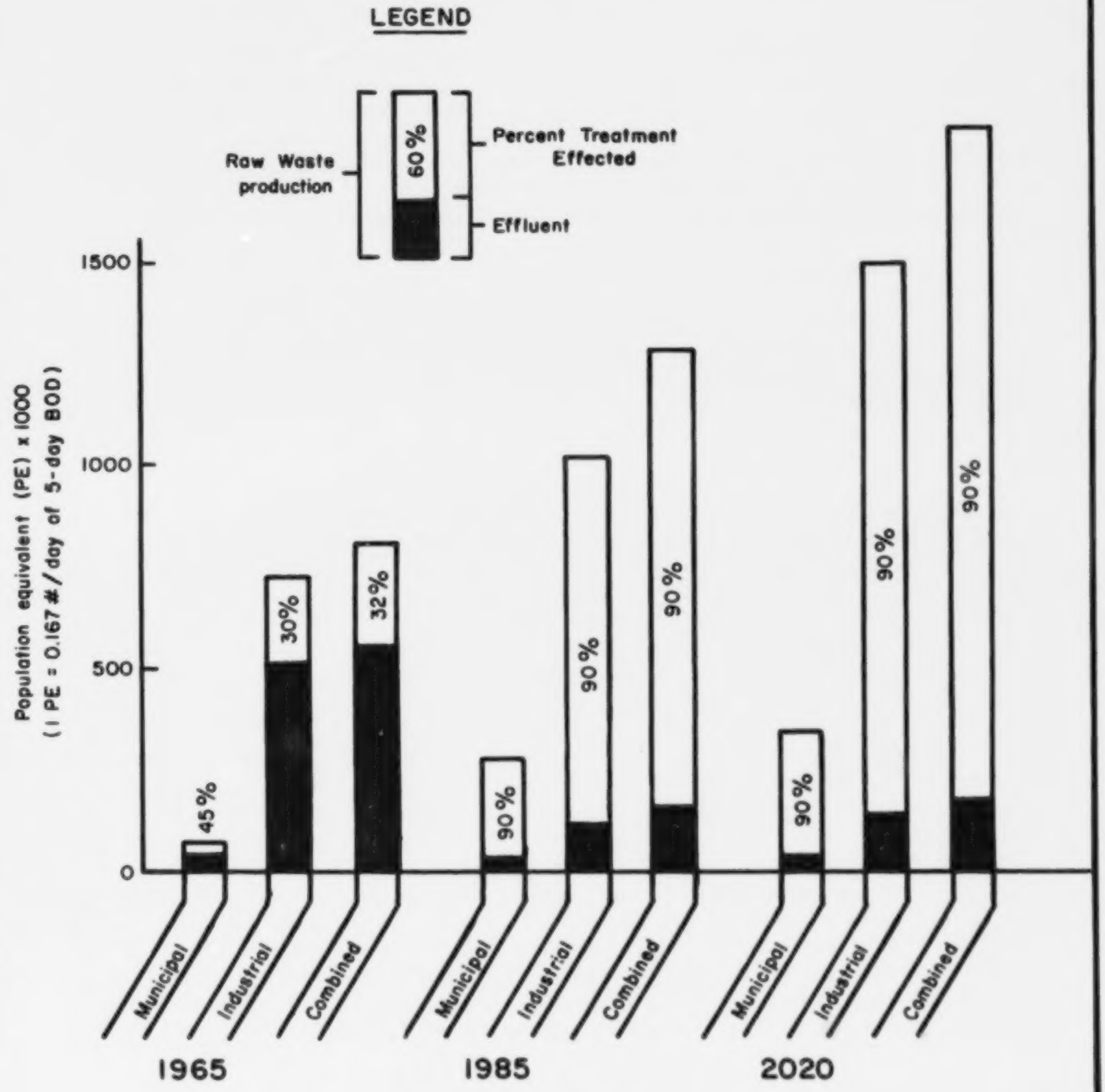
Separately-discharging industries are currently contributing about 90 percent of the total 94,000 lbs/day of 5-day BOD that is reaching the surface waters of the Genesee River and its tributaries. The total loading is the result of about 45 percent treatment by municipalities and 30 percent treatment by industries.

Figure 6 presents a summary of present and projected municipal and industrial wastes. As shown, raw waste production by separately-discharging industries is projected to increase nearly 40 percent by 1985 and nearly 110 percent by the year 2020. Municipal waste production is projected to increase 300 and 500 percent respectively, for 1985 and 2020. With 90 percent treatment anticipated by 1985 the


LAKE ONTARIO
IRONDEQUOIT BAY
New York State Barge Canal
ROCHESTER
ORLEANS
MONROE
GENESEE
CHURCHVILLE
BATAVIA
LEROY
Black Cr
Oatka Cr
Honeoye Cr
HONEOYE FALLS
AVON
LAKEVILLE
CONESUS LAKE
HEMLOCK LAKE
HONEOYE LAKE
CANADICE LAKE
ONTARIO
WYOMING
WARSAW
SILVER LAKE
MOUNT MORRIS
GENESEE RIVER
LIVINGSTON
NUNDA
DANSVILLE
PORTAGEVILLE
ALLEGANY
CATTARAUGUS
STEUBEN
ANGELICA
SCIO
WELLSVILLE
NEW YORK
PENNSYLVANIA
N
SCALE IN MILES
3 0 3 6 9
LEGEND
▨ Zones of significant water quality impairment.
☐ Zones of moderate water quality impairment.
⇨ Untreated or inadequately treated municipal waste.
➡ Untreated or inadequately treated industrial waste.

PRINCIPAL ZONES OF
WATER QUALITY IMPAIRMENT
GENESEE RIVER BASIN

Figure 5



TOTAL MUNICIPAL AND INDUSTRIAL WASTES, PRESENT AND PROJECTED

GENESEE RIVER BASIN

Figure 6

combined municipal and industrial discharge is projected to be 22 percent of the present loading to the basin waters. In the year 2020 the projection is for 33 percent.

In the last five to six miles, the Genesee River is in its most serious state of degradation. Studies in the summer and fall of 1965 revealed that the entire lower reach is almost completely depleted of dissolved oxygen. Five-day BOD concentrations were generally greater than 20 mg/l. Concurrent biological studies showed the bottom fauna consisted almost exclusively of sludgeworms. The numbers of these organisms ranged from 8,000 to 43,000 per square meter.

The discharge from the Eastman Kodak Company's primary treatment plant is the principal cause of this condition. Kodak has secondary treatment facilities in the initial stages of construction, which should greatly reduce the present effluent loading of over 320,000 PE to the river. Contributing to the poor quality of this lower five to six mile sector are intermittent discharges of untreated waste from the thirty combined sewer overflows of the City of Rochester and the latent oxygen demand of the extensive sludge deposits.

Three other reaches on the main stem experience significant impairment of water quality. These are below Curtice-Burns (Mount Morris); the Village of Avon and General Foods, Birdseye Division; and the Gates-Chili-Ogden discharges. At Mount Morris the river receives relatively large quantities of untreated wastes from a cannery, Curtice-Burns, Inc., during the months of low flow. A 40 percent depletion of DO has been observed below the plant's untreated discharge of over 50,000 PE, in terms of BOD.

The reach below the Village of Avon and Birdseye Division discharges is often seriously depleted of DO, grossly discolored, and choked with pollution-stimulated weed and algal growth. Fish kills have often occurred in this stretch; one of massive proportions was reported in 1959. The 5-day BOD from the Birdseye Division Cannery has been estimated at over 17,000 pounds per day during the canning season of June to December. The river recovers gradually in the sluggish reach below Avon, but receives the large Gates-Chili-Ogden primary treatment discharge before being mixed with the Barge Canal waters above Rochester. This municipal plant serves about 30,000 and its effluent causes a moderate depletion in dissolved oxygen.

Among the more seriously degraded reaches on the tributaries to the Genesee River are Honeoye Creek below Honeoye Falls, and Oatka Creek below Warsaw. The stream flow in Honeoye Creek is commonly very low in the summer months because of limited releases from its three headwater lakes of Honeoye, Canadice and Hemlock. In addition, the Honeoye Falls secondary treatment plant does not reduce organic materials sufficiently. The village is presently taking measures to reduce its effluent BOD in order to correct gross pollution conditions--

an extremely low DO and high bacterial counts. Processing waste from a dairy products manufacturer presently overloads the plant.

Studies of Oatka Creek below Warsaw in 1965 revealed a polluted condition existed in the stream for many miles. Less than 1 mg/l of DO was found for miles below the village's primary treatment plant and the Ainsbrook knitting mill discharges. Stream BOD's increased more than 25 mg/l as a result of these discharges. The downstream trout fishery at Wyoming is often damaged when low streamflows extend the polluted conditions at Warsaw.

Oswego River Basin

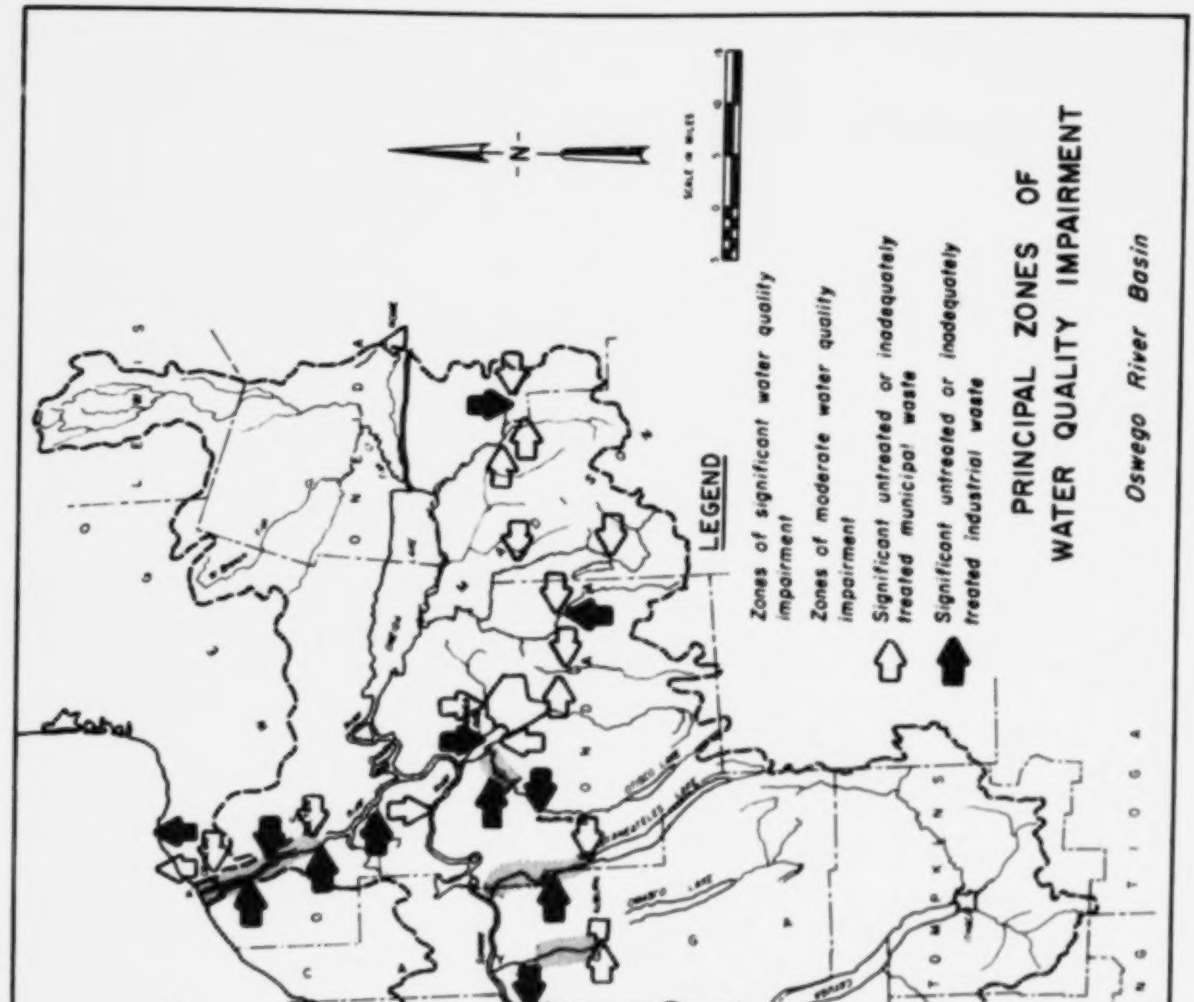
The Oswego River Basin has many areas of serious water quality impairment. Figure 7 is a display of the areas where the major pollution problems exist. Approximately 60 percent of the BOD waste load reaching the streams of the Oswego River Basin is a result of municipal discharges, while the remaining 40 percent is attributed mostly to industries. (See Figure 8.) The major pollution problems include those on Onondaga Lake, the Oswego River near Fulton, the Seneca River in the Waterloo-Seneca Falls area, the Clyde River (Barge Canal) below Newark and others on the outlet of the Finger Lakes.

Syracuse-Onondaga Lake Areas

The Syracuse area is located in the heart of Onondaga County. A majority of the subbasin population and approximately 60 major industries are located in the Syracuse Metropolitan area. This large concentration of population and industry has given rise to water quality problems of equal magnitude. Waste discharges to Onondaga Lake contain large quantities of inorganic and organic materials. Analysis of samples taken during the summer of 1965 from the lake indicated a zone almost devoid of oxygen below the 25 foot depth; conductivities that ranged between 5,000 and 8,000 micromhos/cm; chlorides that range between 1,300 and 3,000 mg/l and five-day BOD's that averaged about 15 mg/l. Biological investigations in July revealed that there was little or no bottom fauna, but there was a large population of pollution-tolerant types of algae ranging up to 100,000 organisms per milliliter. Lake bottom cores revealed layers of sludge, along with sodium and calcium carbonate deposits.

The water quality problems of Onondaga Lake stem from several different sources. (See Figure 9.)

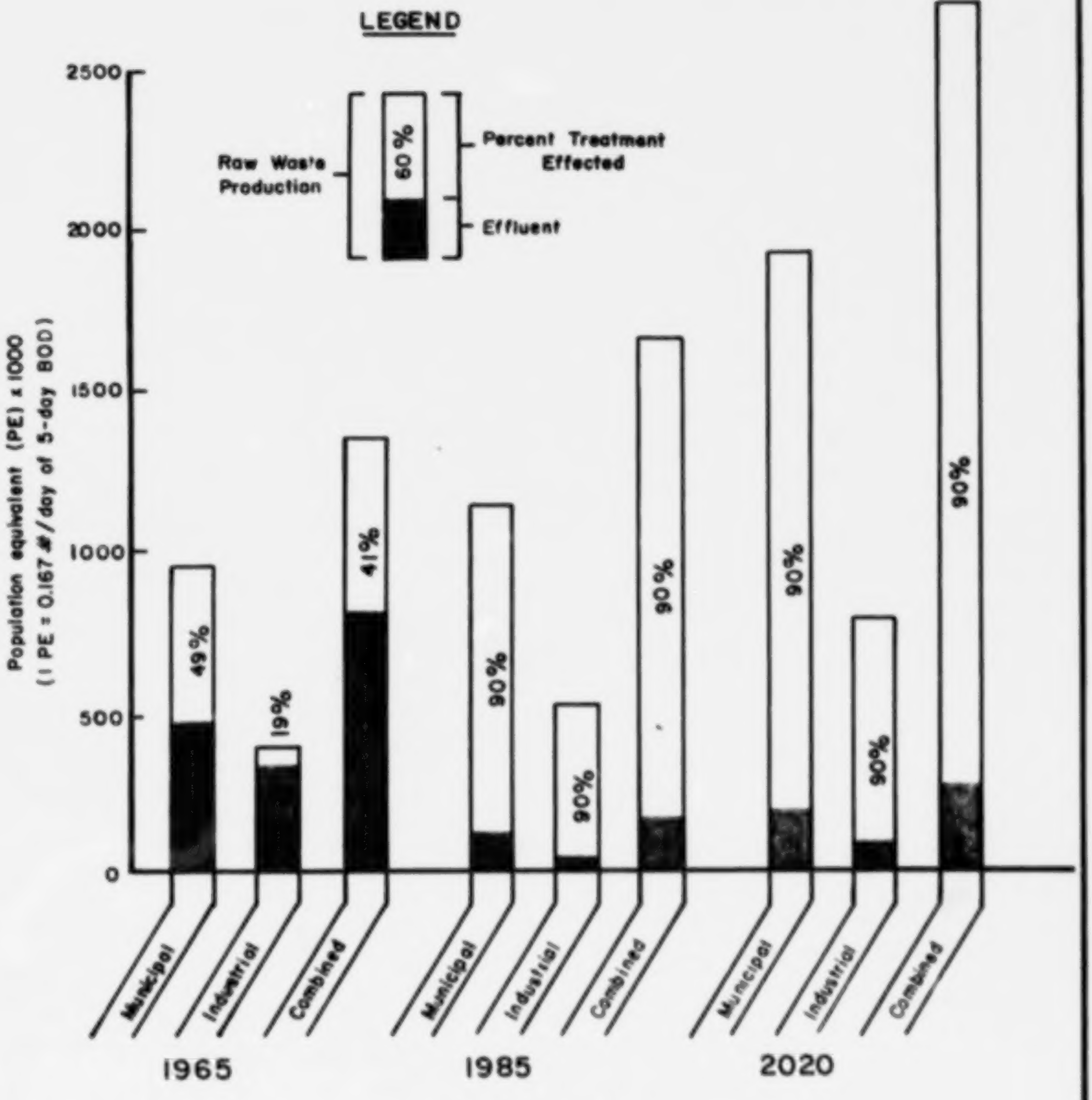
1. Raw or partially treated domestic and industrial wastes are discharged directly to the lake and its tributaries. Major waste contributors discharging directly to the lake are the Metropolitan Treatment Plant and Crucible Steel.


LAKE ONTARIO
MONROE
LIVINGSTON
ONTARIO
WAYNE
CAYUGA
OSWEGO
ONONDAGA
SENECA
YATES
SCHUYLER
STEUBEN
TOMPKINS
CHEMUNG
TIOGA
OTISCO LAKE
SKANEATELES LAKE
OWASCO LAKE
CAYUGA LAKE
SENECA LAKE
KEUKA LAKE
N
SCALE IN MILES
LEGEND
Zones of significant water quality impairment
Zones of moderate water quality impairment
Significant untreated or inadequately treated municipal waste
Significant untreated or inadequately treated industrial waste

PRINCIPAL ZONES OF WATER QUALITY IMPAIRMENT

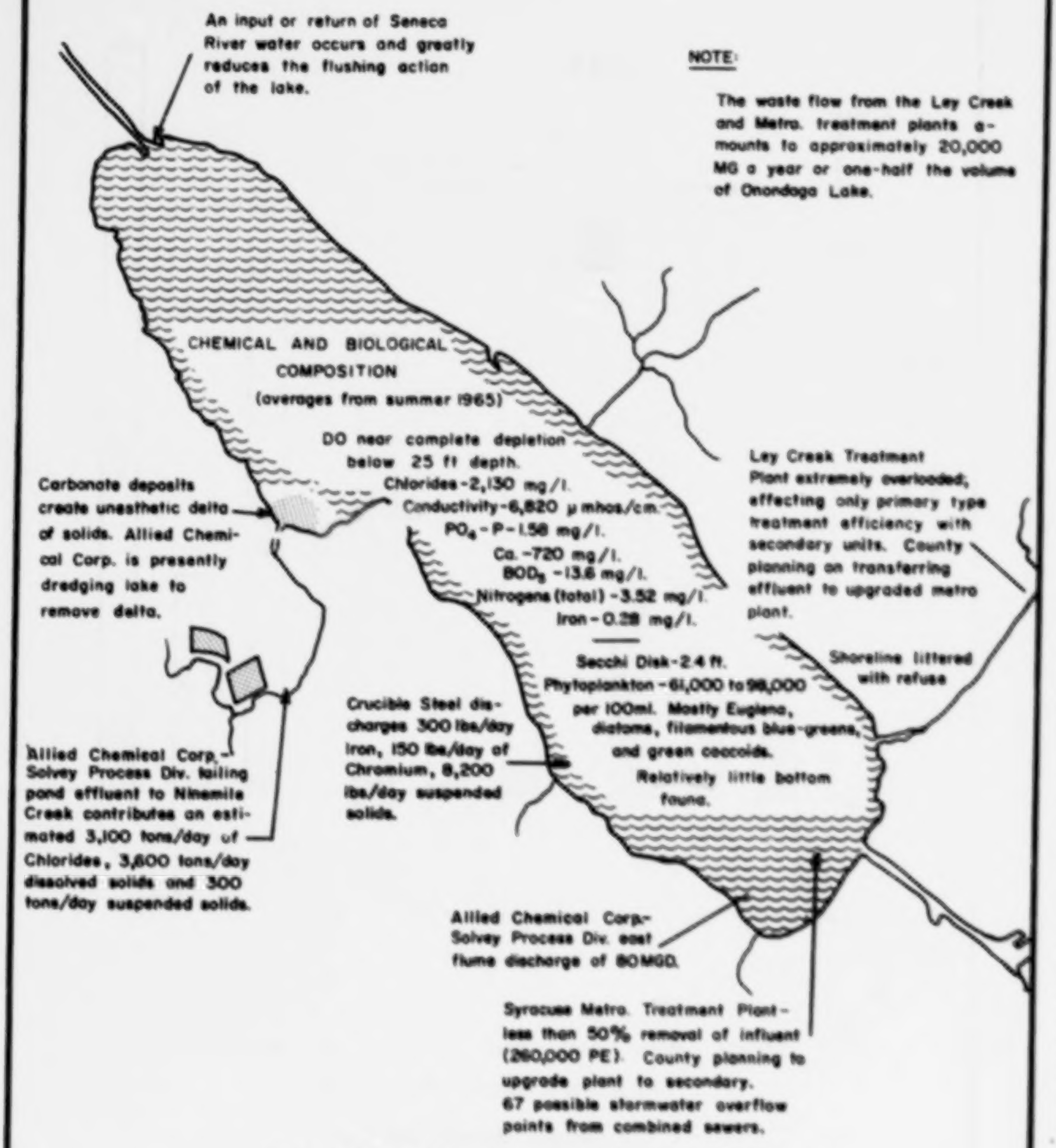
Oswego River Basin

Figure 7



TOTAL MUNICIPAL AND INDUSTRIAL WASTES,
PRESENT AND PROJECTED
OSWEGO RIVER BASIN

Figure 8



An input or return of Seneca River water occurs and greatly reduces the flushing action of the lake.

NOTE:

The waste flow from the Ley Creek and Metro. treatment plants amounts to approximately 20,000 MG a year or one-half the volume of Onondaga Lake.

CHEMICAL AND BIOLOGICAL COMPOSITION
(averages from summer 1965)

DO near complete depletion below 25 ft depth.
Chlorides - 2,130 mg/l.
Conductivity - 6,820 μ mhos/cm.
PO_4 - P - 1.58 mg/l.
Ca. - 720 mg/l.
BOD_5 - 13.6 mg/l.
Nitrogens (total) - 3.52 mg/l.
Iron - 0.28 mg/l.

Secchi Disk - 2.4 ft.
Phytoplankton - 61,000 to 98,000 per 100ml. Mostly Euglena, diatoms, filamentous blue-greens, and green coccoids.
Relatively little bottom fauna.

Carbonate deposits create unesthetic delta of solids. Allied Chemical Corp. is presently dredging lake to remove delta.

Ley Creek Treatment Plant extremely overloaded, effecting only primary type treatment efficiency with secondary units. County planning on transferring effluent to upgraded metro plant.

Shoreline littered with refuse

Allied Chemical Corp. - Solvey Process Div. tailing pond effluent to Ninemile Creek contributes an estimated 3,100 tons/day of Chlorides, 3,600 tons/day dissolved solids and 300 tons/day suspended solids.

Crucible Steel discharges 300 lbs/day iron, 150 lbs/day of Chromium, 8,200 lbs/day suspended solids.

Allied Chemical Corp. - Solvey Process Div. east flume discharge of 80 MGD.

Syracuse Metro. Treatment Plant - less than 50% removal of influent (260,000 PE). County planning to upgrade plant to secondary. 67 possible stormwater overflow points from combined sewers.

POLLUTION PROBLEMS IN
ONONDAGA LAKE

Figure 9

2. It was reported in 1961 that wet weather overflows from the city's combined sewer system occurred on the average of 48 times a year. These periodic overflows carried large quantities of untreated sewage to the lake.

3. There have been large accumulations of both organic and inorganic sediments during the past century. Effluents from Allied Chemical Company's Solvay Division contain mostly inorganic wastes consisting of calcium compounds (chlorides, sulfates, hydroxides and carbonates) and sodium chlorides. Precipitates of these white materials have built up a delta at the confluence of Ninemile Creek and Onondaga Lake. (See Plate 2.) Recently, Solvay joined Onondaga County in dredging these wastes which will be used for lowland fill along the lake.

4. The natural hydrologic phenomenon of the lake presents an additional problem. An analysis of the outlet indicates that the flows are relatively small and that there appeared to be an occasional return of Seneca River water in the upper layers. Apparently little flushing action is achieved which, in turn, greatly reduces the assimilative capacity of the lake.

Onondaga Lake receives more nutrients than any other lake in the Basin. Despite high concentrations of chlorides and suspended solids, the lake is clogged with heavy growths of algae. Light penetration is less than three feet. All of these factors reflect a severely degraded environment. (See Plate 3.)

Oneida Lake

Oneida Lake is in a highly advanced state of eutrophication, resulting partly from the input of large quantities of nutrients from poorly treated municipal and industrial wastes.

The nutrients, along with ideal physiographic features, promote prolific algal blooms which decay into foul-smelling masses and eventually wash ashore. These repugnant conditions are a deterrent to most water uses. Major tributaries receiving large waste loads are Chittenango Creek, including Limestone and Butternut Creeks, and Oneida Creek, including Sconondoa Creek and Canaseraga Creek. In addition, a larger portion of the nutrients apparently is due to natural runoff which includes that portion attributable to agricultural activity. There are many direct discharges from cottages, plus vessel wastes from the Barge Canal traffic and a large number of pleasure craft.

Results of the 1965 survey revealed that Oneida Lake has indeed reached an over-enriched state conducive to prolific plant growth. Phosphate levels were found to be consistently high. Other indications of Oneida Lake's deteriorated condition are its limited transparency, and increasing alkalinity.

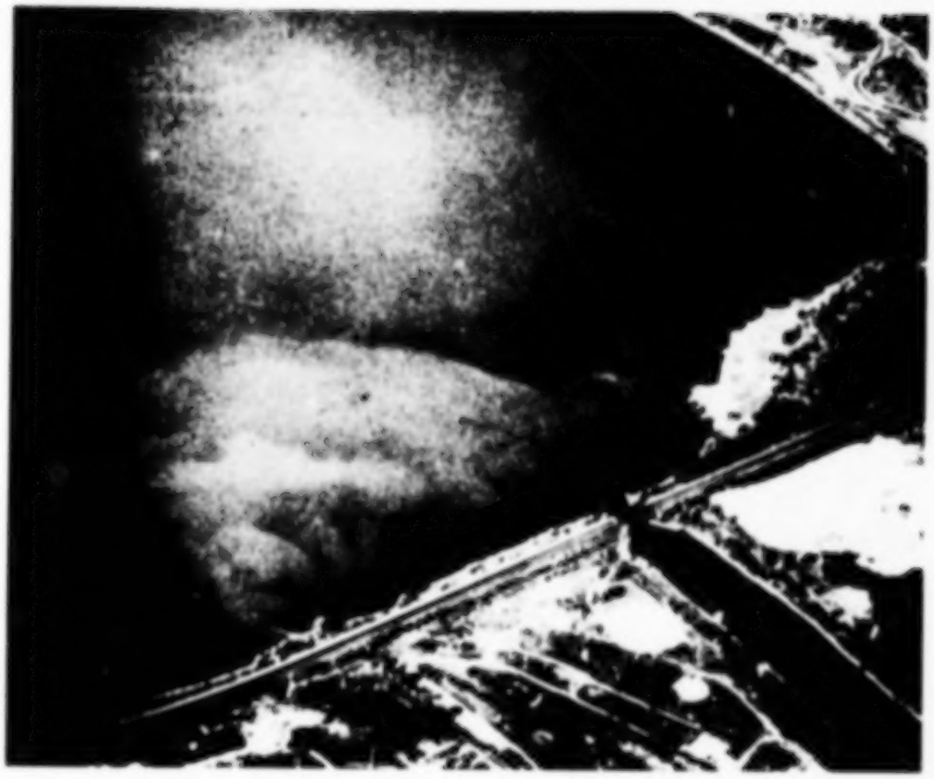


PLATE NO. 2 - Sewage treatment plant discharge into Lake Onondaga at Syracuse.

A summary of the estimated sources of phosphate to Oneida Lake is shown in Figure 10. For the Basin as a whole approximately 40 percent of the total phosphate loading is the result of municipal and industrial waste discharges direct to the lake or its tributaries. Also shown in Figure 10 is the relative fraction of the total input from each tributary stream.

Finger Lakes Region

The Finger Lakes have large volumes and controlled outlet flows, so that seasonal variations in precipitation do not radically affect them. The large lake volumes also provide considerable dilution for waste inputs and the eventual assimilation of most wastes. Further, these large natural storage reservoirs permit a more gradual release of water to the outlets, preventing extremely low flows in the outlets.

There are areas of localized pollution at Ithaca, Geneva, Dresden and on the lake outlets. The two areas of poor quality on Seneca Lake are at Dresden, where the pollution-laden Keuka Outlet adversely affects the lake, and on the north shore at Geneva, where the city has had to restrict swimming. This area is principally affected by the discharge from the city's primary treatment plant but also by some industrial discharges to tributaries and city storm sewers.

On Cayuga Lake, the beaches in the Ithaca area have had to be closed because of bacterial pollution and because dense growths of plankton make the local waters hazardous to swim in by limiting transparency.

The two Finger Lakes outlet streams most seriously degraded are Skaneateles Creek and Owasco Outlet. The flow in Owasco Outlet is regulated to preserve the storage in Owasco Lake for water supply. Only a nominal amount is allowed for dilution of domestic wastes. Odors are common during low flows. Skaneateles Creek is also regulated closely, since the lake presently is the major source of water supply for the City of Syracuse. There is bacterial contamination throughout Skaneateles Creek and in some reaches, high pH, turbidity and color result from poorly treated industrial wastes, especially in and below Skaneateles Falls.

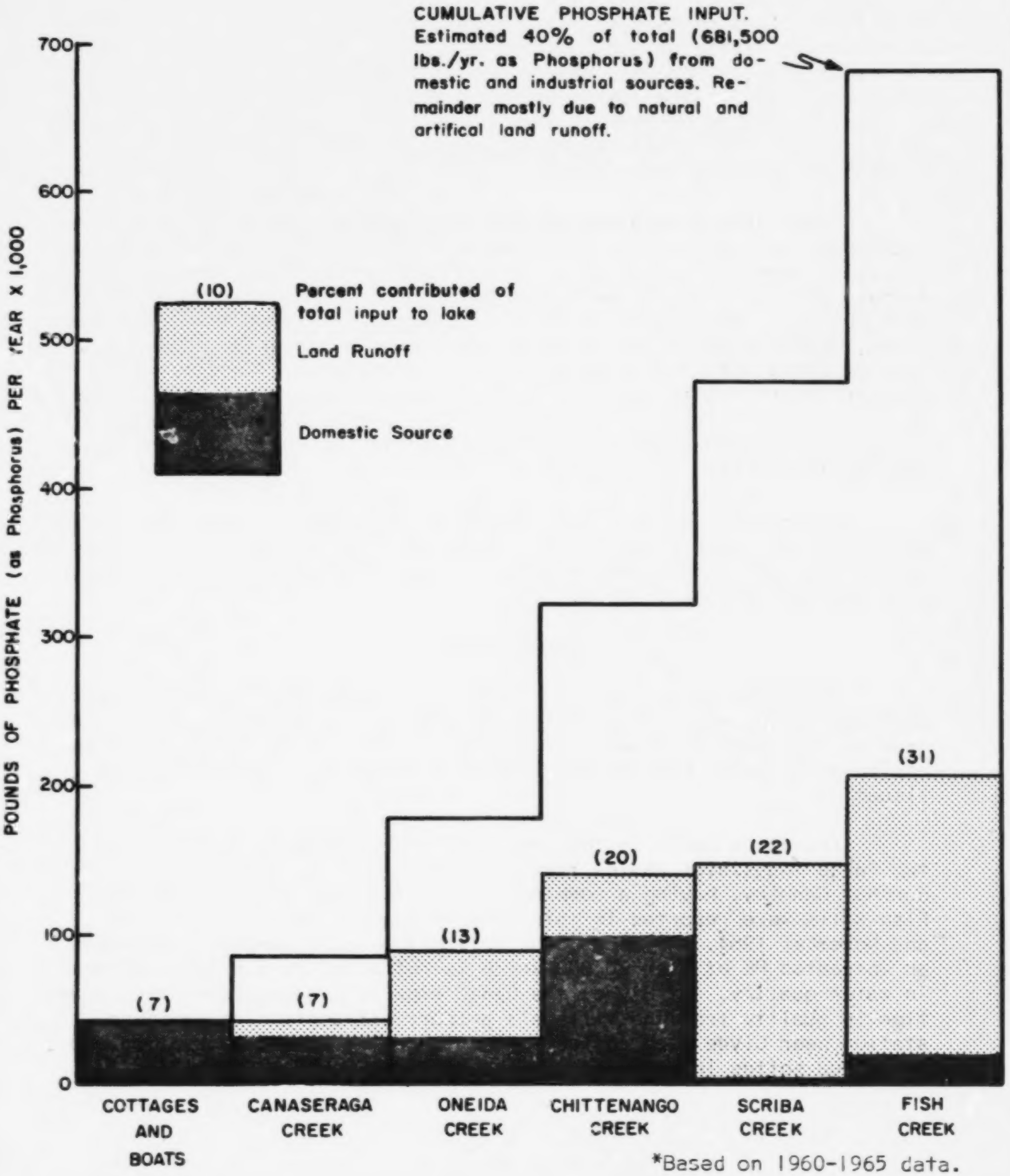
Wineries on both Keuka Inlet and Naples Creek (Canandaigua Inlet) impose sizeable organic loads on those streams. Particularly at Hammondsport on Keuka Inlet, both chemical and biological data reflected the additional loading imposed by the wineries in the fall.

The Seneca and Cayuga Lake Outlets together form a part of the Cayuga-Seneca section of the Barge Canal System; this 13 mile reach is extremely polluted. Many fish kills have been reported below Waterloo and Seneca Falls; of note were the extensive fish kills reported in October 1961, September 1962, and October 1963.

PLATE NO. 3 - Debris littering southeast shore of Lake Onondaga.

ANNUAL PHOSPHATE CONTRIBUTIONS TO *ONEIDA LAKE*

SHOWING FRACTIONS OF DOMESTIC AND LAND RUNOFF FOR EACH SOURCE*



CUMULATIVE PHOSPHATE INPUT. Estimated 40% of total (681,500 lbs./yr. as Phosphorus) from domestic and industrial sources. Remainder mostly due to natural and artifical land runoff.

*Based on 1960-1965 data.

Figure 10

The cause of this degradation is principally industrial wastes, and to a lesser extent the poorly treated municipal waste of the Villages of Waterloo and Seneca Falls. Sylvania Electric discharges an untreated waste of about 6,000 PE that is high in fluorides. Evans Chemetics and Seneca Knitting Mills discharge significant quantities of untreated waste. Evans' discharges include large quantities of dissolved solids containing soluble sulfides and sulfates, along with intermittent discharges which include high organic loadings and quantities of zinc. A cannery severely overloads the Waterloo Sewage Treatment Plant in the summer and fall months, raising the strength of the influent to between 10 and 20 times the normal 5,000 PE received at the plant. The river is grossly discolored by cannery waste for several miles below the outfall.

Flows from Seneca and Cayuga Lakes are regulated for both hydropower and Barge Canal navigation. Unfortunately, other purposes, including low-flow augmentation receive only minor consideration. Average 24-hour flows to meet peak power demands have varied from 60 to 1,000 cfs. Because of the wide fluctuation of flows into the Seneca River, Geneva's waste discharges to Seneca Lake appear on occasion to flow directly into the river with little dispersion. This is of particular importance to the City of Waterloo, whose water supply intake is only a short distance downstream. Also because of this, wastes are frequently carried downstream in slugs, contributing to the conditions causing fish kills.

Over-fertilization is a problem on the Finger Lakes. The aquatic weed problems found primarily on the northern end of Seneca Lake and the substantial plankton blooms which occur at the southern end of Cayuga Lake are indications of this.

Barge Canal

The Barge Canal reach from Newark to Lyons has excessive organic loadings which result in a serious depletion of dissolved oxygen. The flow in the Canal is diverted to Ganargua Creek above Newark and does not re-enter until nine miles downstream at Lyons, complicating the situation.

The Barge Canal in the immediate area of Newark is subjected to two large industrial wastes from Perfection Canning and Edgett and Burnham Cannery, having a combined population equivalent of 28,000. Fish kills were reported in this area in August 1961, October 1963 and November 1964. At Lyons, the National Biscuit Company discharges an untreated PE of over 20,000 which is reflected by a slight decrease in water quality. At Clyde, the Canal experiences moderate deterioration in quality from the Village's primary effluent. The sampling station near Clyde also reflects high concentrations of dissolved and suspended solids in addition to high bacteria counts.

Two main tributaries to this section of the Canal, Mud Creek near Macedon and Canandaigua Outlet below Newark, apparently contribute large quantities of dissolved and suspended solids.

Oswego - Fulton Area

The Oswego River from Three Rivers to Lake Ontario is a pollution-laden stream that discharges nearly 6,300 cfs to Lake Ontario. The river is high in dissolved and suspended organics at its headwaters and receives untreated domestic sewage from three communities and untreated industrial wastes from six large and many small industries.

At Fulton, the canalized section between two locks is extremely polluted. Discharged to the river above and in this section are the raw wastes of the town's 14,000 residents,* a large General Foods-Birdseye Division food-processing plant, the Nestle Company, Sealright Container Corporation, and North End Paper. Together, these industries contribute an organic loading equivalent to a population of more than 77,000.

Just two miles downstream of Fulton, Armstrong Cork adds another untreated loading of 44,100 PE. Its discharge has created an unsightly delta of deposits in the river below the outfall. Farther downstream, bottom deposits are resuspended by passing tugs, making the river a dark unsightly color as it passes Battle Island State Park. Finally before entering Lake Ontario, the river receives a raw waste discharge from the City of Oswego, which has nearly 31,000 people.

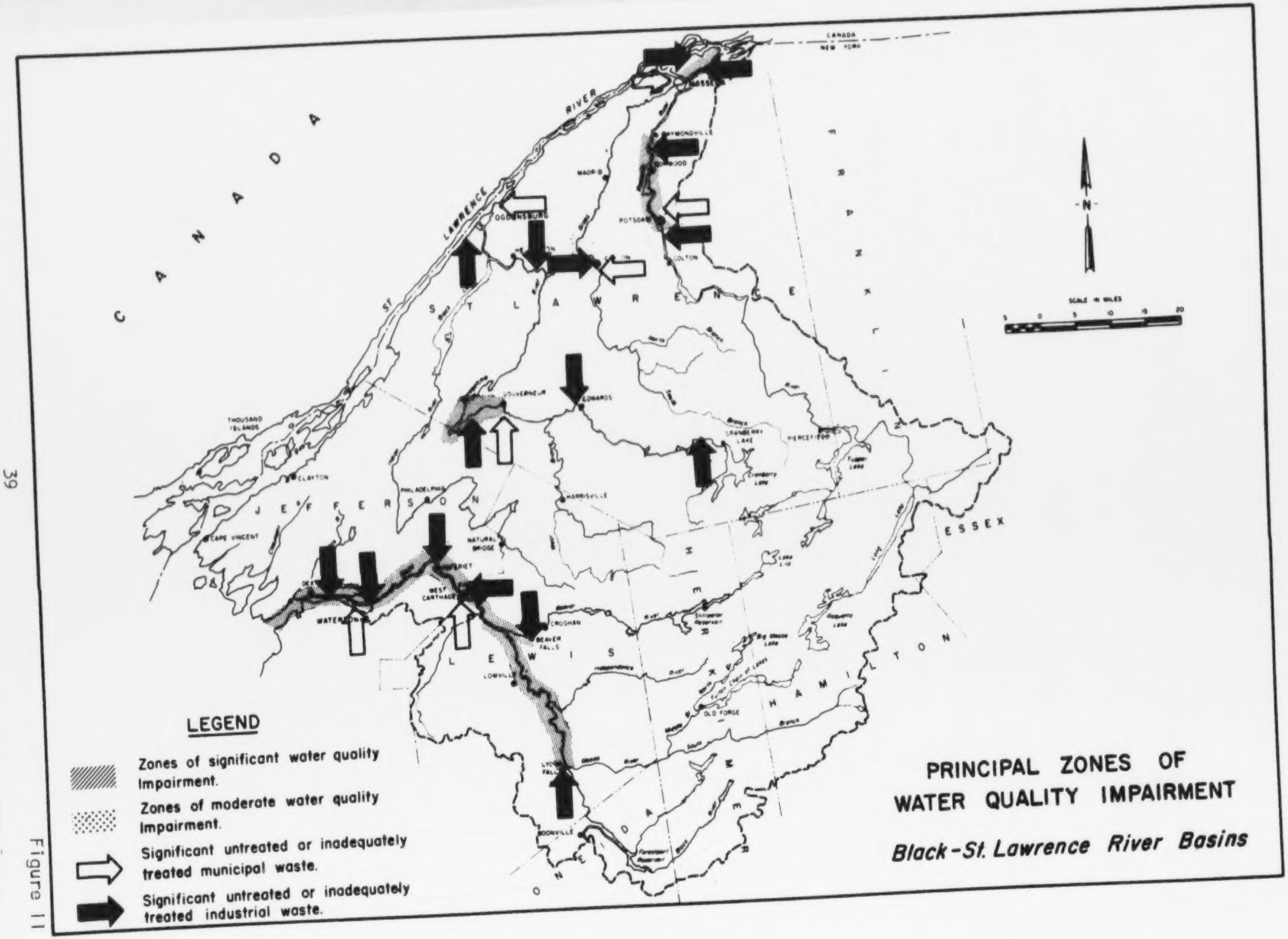
Black-United States St. Lawrence River Basins

The Black-United States St. Lawrence River Basins have many areas of serious water quality impairment despite the fact that the streamflows are generally large. There are many headwater lakes that could be regulated for water quality control.

Figure 11 contains a display of the major problem areas. The central and lower sections of the Black River are the most seriously affected reaches. Sectors on the upper and lower Oswegatchie River, the lower Grass, and the lower Raquette also have serious pollution problems. The St. Lawrence River, in the 114-mile stretch between Lake Ontario and Massena covered in this report, exhibits localized pollution at Ogdensburg and Massena.

Over 90 percent of the total organic loading of 900,000 PE, in terms of BOD, to the waters of the Black-United States St. Lawrence River Basins is contributed by pulp and paper manufacturers. Of lesser significance but still a cause of water quality degradation are waste discharges from aluminum processing plants, dairy products plants, and

*Treatment plant completed by Fulton in 1968.


CANADA
NEW YORK
C A N A D A
ST LAWRENCE RIVER
S T L A W R E N C E
F R A N K L I N
J E F F E R S O N
L E W I S
H A M I L T O N
H E R K I M E R
O N E I D A
ESSEX
MASSENA
RAYMONDVILLE
NORWOOD
POTSDAM
COLTON
MADRID
OGDENSBURG
GOUVERNEUR
EDWARDS
CRANBERRY LAKE
Cranberry Lake
PIERCEFIELD
Tupper Lake
HARRISVILLE
THOUSAND ISLANDS
CLAYTON
CAPE VINCENT
PHILADELPHIA
NATURAL BRIDGE
WEST CARTHAGE
WATERTOWN
CROGHAN
BEAVER FALLS
LOWVILLE
LYONS FALLS
BOONVILLE
OLD FORGE
Stillwater Reservoir
Big Moose Lake
Raquette Lake
Long Lake
Lake Lila
Fulton Chain of Lakes
Forestport Reservoir
N
SCALE IN MILES
5 0 5 10 15 20
LEGEND
Zones of significant water quality impairment.
Zones of moderate water quality impairment.
Significant untreated or inadequately treated municipal waste.
Significant untreated or inadequately treated industrial waste.

PRINCIPAL ZONES OF WATER QUALITY IMPAIRMENT

Black-St. Lawrence River Basins

Figure 11

mining operations. Little or no treatment is provided by industries. Municipalities are also causing pollution problems due to inadequate treatment. Only about 30 percent reduction of BOD is provided through existing municipal treatment facilities. Figure 11 also shows the location of the major municipal and industrial discharges.

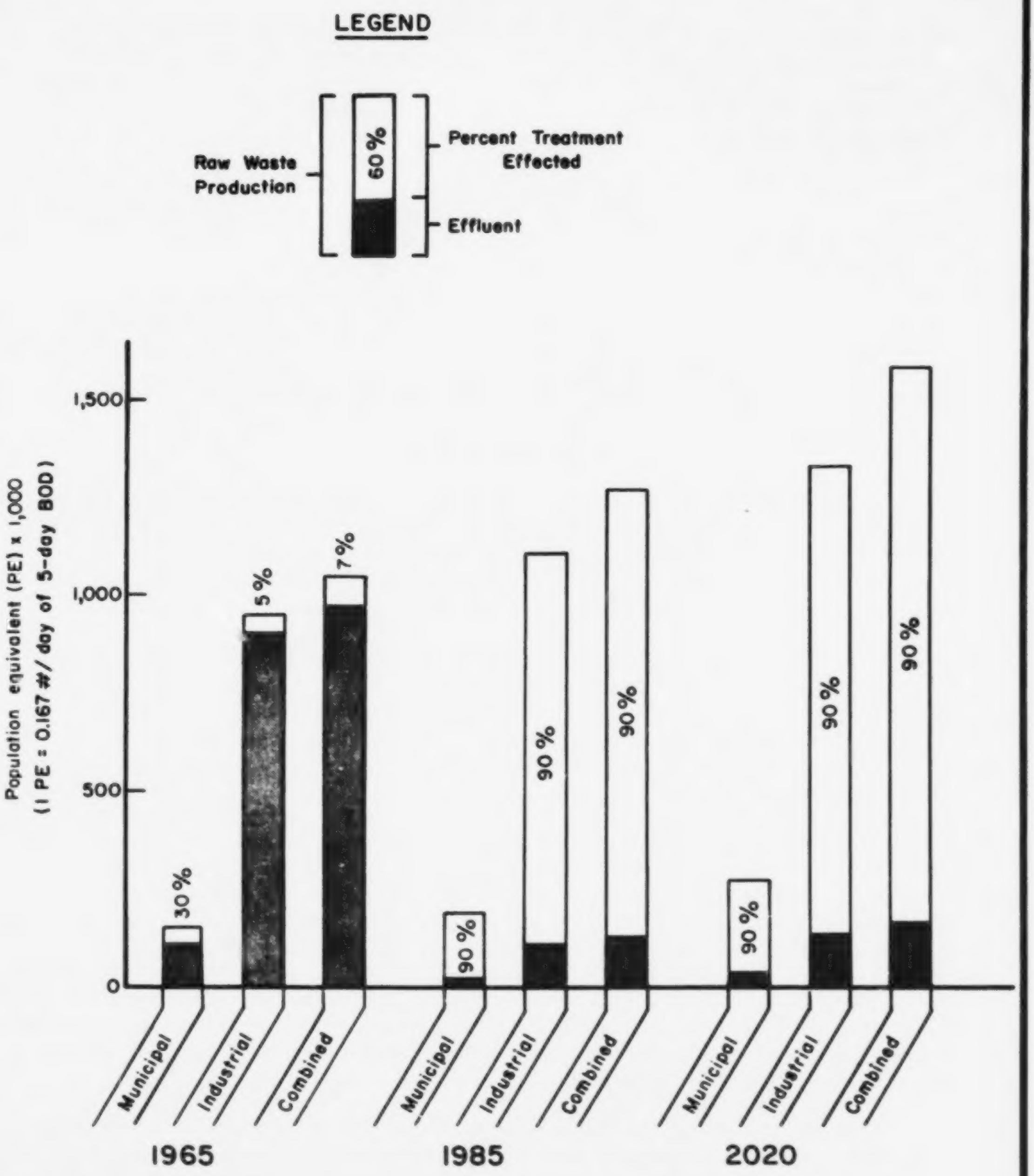
Figure 12 summarizes the present and projected municipal and industrial waste loadings to the Basin waters. As shown, raw waste production by separately-discharging industries is projected to increase nearly 15 percent by 1985 and about 45 percent by the year 2020. Municipal waste production is projected to increase about 20 percent and 70 percent by the years 1985 and 2020. With 90 percent treatment anticipated to be in effect by 1985 the combined municipal and industrial loading to the Basin waters is projected to be 20 percent of the present in 1985, and 45 percent of the present in 2020.

Black River Area

The Black River is in a severely polluted condition; the cause is primarily the numerous untreated waste discharges of pulp and paper mills. The area affected covers the lower half of the Basin or more than 80 miles of river. The stream sectors below Lyons Falls, Beaver Falls, Carthage and Watertown are the most critically affected.

Pollution in the Black River is primarily in the form of excessive organic loadings and related dissolved oxygen depletions, gross discoloration and fouling of the water surface with multi-colored foams and floating debris, and the buildup of vast deposits of paper fibers, wood chips, and other oxygen consuming materials on the streambed. Dissolved oxygen profiles of the Black River made by the National Council for Stream Improvement in 1965 revealed that the entire 40 mile sector from the Georgia Pacific pulp and paper mill to Carthage had less than 4 mg/l and less than 2 mg/l for ten miles of this reach. This was at a time when the streamflow was about 600 cfs below Lyons Falls or more tnan three times the critical low flow for this reach. The Georgia Pacific mill at Lyons Falls discharges an untreated waste of between 37,000 and 50,000 lbs/day 5-day BOD and this was reflected in the stream by a three- to fourfold increase in BOD. Suspended solids from this mill were measured at nearly 70,000 lbs/day. Huge rafts of floating scum and white foam have been observed completely covering the river for over a mile downstream. (See Plate 4.)

Another serious problem exists below the Carthage-Deferiet area. St. Regis, Crown Zellerback and Carthage Paper Makers were found discharging without treatment over 60,000 lbs/day 5-day BOD to this reach in a Federal Water Pollution Control Administration survey in 1965. Downstream of this loading, of which 70 percent is from St. Regis' pulp and paper mill, the DO was recorded as low as 2.7 mg/l during moderate flows. Calculations of DO concentrations during periods of low streamflow show expected levels to be less than 1 mg/l. The



TOTAL MUNICIPAL AND INDUSTRIAL WASTES,
PRESENT AND PROJECTED

BLACK - U.S. ST. LAWRENCE RIVER BASINS

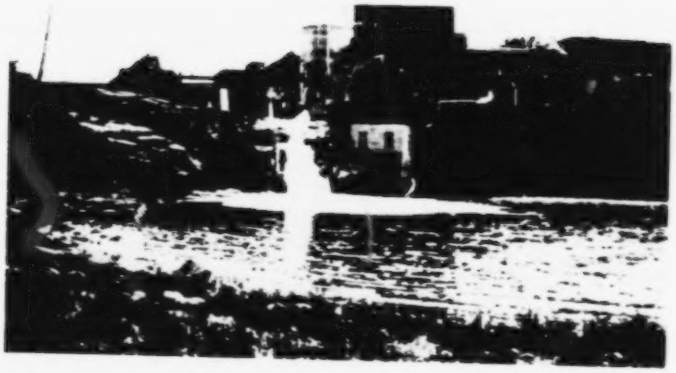


PLATE NO. 4 - Untreated wastes from paper mills discharging into Black River at: Lyons Falls (upper) and Carthage (lower).

streambed below the St. Regis mill was observed having a decaying fibrous mat 1 to 2 feet in depth as far downstream as Camp Drum, a distance of nearly 3 miles. Numerous outcroppings or islands of this material were also observed immediately downstream of this mill.

Other areas of the Black River and its tributaries, notably below Watertown and Beaver Falls, have serious water pollution problems. The total discharge to the Black River and its tributaries from pulp and paper mills is about 700,000 PE and from municipalities about 50,000 PE. The City of Watertown, the largest municipality in the Basin, has primary treatment for a population of approximately 40,000.

St. Lawrence Area

The St. Lawrence River, with its enormous flow averaging over 240,000 cfs, is relatively unaffected by either direct waste inputs or the tributary inputs, but does experience areas of localized pollution. In the approximately 115 miles of river between Lake Ontario and the point above Massena where the International boundary departs from the river, there are two locations that receive wastes in quantities significant enough to cause serious degradation in quality. At Massena, wastes from the General Motors-Chevrolet Division aluminum casting plant and the Reynolds metals aluminum reduction plants cause a milky, oily appearance to the river.

At Ogdensburg, the Diamond National paper plant discharges raw wastes, including nearly 7,000 lbs/day of 5-day BOD, floating fibers, wood chips and rafts of white foam. An unsightly discoloration is caused along the shoreline, despite the paper mill's efforts to trap and remove the larger suspended material with a floating barrier. Municipalities that have discharges to the St. Lawrence, with the exception of Ogdensburg and Waddington which have primary treatment, discharge their waste to the river untreated.

The chemistry of the St. Lawrence River, as shown in Table 3 which summarizes the available data for the past decade, reveals little change in quality.

The major tributaries of the St. Lawrence River, the Raquette, Grass and Oswegatchie Rivers, all have localized areas of pollution. The quality of the reach between Potsdam and Raymondville on the Raquette River is often degraded with oxygen deficiencies and gross discoloration. Improper streamflow regulation by upstream hydropower interests compounds the pollution problems created by industrial and municipal waste discharges. Upstream river flows have been completely interrupted for periods up to 14 hours at times, disallowing any dilution for water quality control. Two large paper mills, Nekoosa-Edwards and Northland have a combined discharge untreated, of about 60,000 PE. In addition the Villages of Potsdam, Unionville, and Norwood all discharge their waste, about 16,000 PE, untreated to the river.

TABLE 3

WATER QUALITY DATA - ST. LAWRENCE RIVER, 1955-1966
(Results are Averages in mg/l Unless Otherwise Stated)

Date	No. of Samples 1/	Water Temp. (°C)	pH (Range)	BOD	COD	NO_3	NH_3	Cl	Alkalinity ($CaCO_3$)	Total Hardness($CaCO_3$)	Turbidity (Scale Units)	SO_4	PO_4(as PO_4)	Total Diss. Solids	Conductivity (micromhos/cm)	Coliforms 2/ (/100 ml)
Data Collected at Ogdensburg by U. S. Geological Survey																
10/55-12/55	9	8	7.2-7.9	-	6.3	0.74	-	22	113	162	-	25	-	179	307	-
1/56-9/56	35	10	6.8-7.9	-	6.8	1.10	-	21	111	156	-	26	-	183	297	-
Data Collected at Massena as a Part of National Water Pollution Surveillance System																
10/61-12/61	17	10	7.7-8.2	-	10.0	-	-	27	86	124	21	26	0.02	191	-	326
1/62-9/62	45	11	7.5-8.5	-	12.0	-	0.20	25	88	123	14	30	0.01	192	-	402
10/64-12/64	13	9	7.8-8.2	-	-	-	-	25	89	126	25 3/	28	-	189	-	89
1/65-12/65	52	10	7.7-8.3	-	-	-	-	24	89	124	27 3/	29	-	188	-	193
1/66-6/66	21	5	7.8-8.2	-	-	-	-	22	90	125	26 3/	-	-	189	-	70
Data Collected at Ogdensburg by Federal Water Pollution Control Administration																
4/65-9/65	7	12.6	7.8-8.4	4.9	7.8	0.11	0.14	25	88	-	-	34	0.03	170	273	-
2/66-10/66	9	10	7.4-8.3	1.3	8.6	0.14	0.09	29	94	-	1.4	31	0.09	193	312	-

- Indicates no data available.

1/ Value represents number of times any results were recorded. Many parameters were not analyzed on each sampling occasion. Composites were considered as one sample in showing number of samples but were given appropriate weight in computing average concentrations.

2/ Arithmetic average.

3/ Sensitivity at which test was performed was 25 scale units. Average shown contained numerous values of 25.

The only reaches significantly deteriorated in quality on the Grass River are below Canton and Massena. Sources of pollution in the Canton area include untreated discharges by a Kraft Foods cheese plant--about 7,500 PE in terms of BOD, several dairies, and poorly treated effluents from the Village of Canton's primary treatment plants. An unsightly milky discoloration often exists in the river in and below Canton. The major sources of the moderate pollution found at Massena are the primary treated effluent from the Massena sewage treatment plant (connected population of about 16,000) and the industrial waste discharge of Alcoa. The latter is a 20 MGD effluent from a settling and oil separation lagoon that gives an oily appearance to the river on occasion and causes a buildup of sludge deposits in the streambed.

The quality of the Oswegatchie River is similar to the other major river systems in the St. Lawrence area; it is good except in localized areas which receive untreated or poorly treated municipal and industrial wastes. Stream studies in 1960 and 1965 below Newton Falls revealed high organic loadings and related dissolved oxygen depletions. However, the Newton Falls Paper Company has recently installed extensive treatment facilities to correct the pollution problem. Erratic and insufficient releases from Cranberry Lake often provide inadequate streamflows for proper water quality control.

In and below Gouverneur the river receives about 50,000 PE of organic loading. No treatment is provided by either Borden's (20,000 PE), Vanity Fair Paper (25,000 PE) or the Village (5,000 PE). Severe discoloration was observed downstream of the paper mill as well as great quantities of fibrous, oxygen-consuming sludge deposits on the streambed.

At Heuvelton or about twelve miles before the Oswegatchie River enters the St. Lawrence River it is again subjected to a slug of untreated industrial waste. The Aiello Dairy Farms cheese plant is the major waste contributor. In July 1965 an extensive fish kill occurred in a two-mile sector below Heuvelton.

Minor Tributary Subbasins

The minor tributary area to Lake Ontario covered in this section extends along a strip of shoreline from the Black River to the Niagara River, is about 200 miles long, and averages about 12 miles wide. The area supports a population of 825,000 in ten counties, with the major portion of the people living in the industrialized counties of Monroe and Niagara. The other eight counties are predominantly rural and support agricultural related industries.

Perhaps the most important single body of water in the Minor Tributary study area is a part of Lake Ontario itself but, for the purpose of this report, is called the Rochester Embayment. The embayment includes the Monroe County shoreline including Irondequoit Bay and Creek. Eighteenmile Creek and the Barge Canal are two other significant watercourses in the study area.

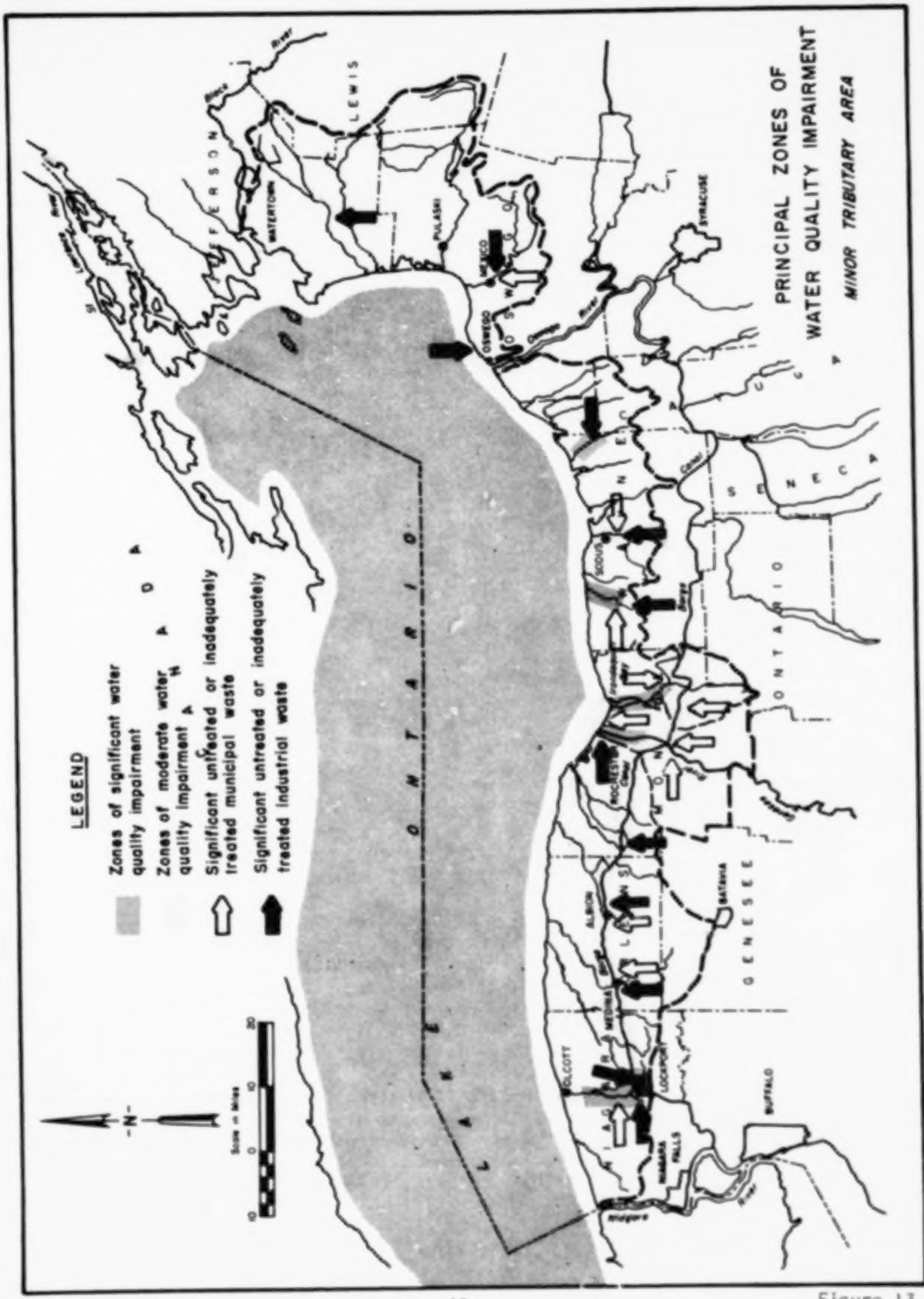
Rochester Embayment

The main pollution problem in this study area is centered around the Rochester Embayment. It involves the beaches, sewer outfalls and water intakes. Partially treated domestic sewage with a population equivalent of over a million is discharged to the embayment. Municipal and industrial wastes from a rapidly growing metropolitan area have complicated water uses in the embayment area. High bacterial counts from metropolitan sewage have caused the main public beaches on the embayment to be closed. The expanding Rochester metropolitan area population with its domestic waste and nutrient load is fast making Irondequoit Bay a highly fertilized waste treatment unit. Algal blooms in the bay attest to this fact. (See Plate 5.)

By far the worst offender in degrading the waters of the Rochester embayment is the City of Rochester with its facilities. Some 80 million gallons a day of primary treated waste with a population equivalent of over 700,000, is discharged through a single 7,000 foot outfall to the embayment. The city's partially treated and chlorinated sewage is discharged offshore from two of the city's major public beaches. Current, wind and temperature are major factors in the movement of the waste in and around the embayment in slugs or dispersed masses. The waste is a potential health hazard to swimmers and to the metropolitan drinking water supplies. (See Figure 13.)

Metropolitan growth and population explosion have engulfed the Irondequoit Bay and Creek basin. The Villages of East Rochester and Fairport and the Towns of Brighton, Irondequoit and Penfield discharge waste treatment effluents with an estimated population equivalent of 12,500 to the Irondequoit waters. This waste loading is also a detriment to Irondequoit Bay. Good water and adequate flows from the canal protect Irondequoit Creek and its two main tributaries from total deterioration and flush the nutrients in the waste into the bay. The nutrients more or less become trapped in the bay, deposited on the bottom or taken up in the life cycles of the biota. Industry also contributes minor amounts of waste to the watershed but does not by any degree approach the domestic sewage loadings. Lack of interchange or dilution of Lake Ontario and Irondequoit Bay water, minimum flows in Irondequoit Creek creating no flow through the bay, or inefficient removal of nutrients at contributing sewage treatment plants in the Irondequoit Basin means continued concentration of nutrients in the bay.

PLATE NO. 5 - Webster Beach east of Rochester. Mounds of odorous decaying algae pile up along the entire Lake Ontario shoreline.


LEGEND
Zones of significant water quality impairment
Zones of moderate water quality impairment
Significant untreated or inadequately treated municipal waste
Significant untreated or inadequately treated industrial waste
-N-
Scale — Miles
10
0
10
20
C A N A D A
L A K E O N T A R I O
JEFFERSON
LEWIS
WATERTOWN
PULASKI
MEXICO
OSWEGO
Oswego River
SYRACUSE
Canal
SODUS
WAYNE
CAYUGA
SENECA
ONTARIO
ROCHESTER
MONROE
Genesee River
ORLEANS
ALBION
MEDINA
BATAVIA
GENESEE
NIAGARA
OLCOTT
LOCKPORT
NIAGARA FALLS
BUFFALO
Niagara River
St. Lawrence River
Black River

PRINCIPAL ZONES OF WATER QUALITY IMPAIRMENT

MINOR TRIBUTARY AREA

Figure 13

Eighteenmile Creek and Barge Canal

The community of Lockport, and nearby industries on the Barge Canal, pollute and degrade Eighteenmile Creek for almost its entire length. Dams on the watercourse place further burdens on the oxygen content of the creek waters, cause concentration of nutrients in the ponded areas, and are a factor in algal blooms in the lower reaches.

Industries including Flintkote Company, United Board and Carton, and the City of Lockport, discharge partially treated waste with a population equivalent of approximately 73,000 to Eighteenmile Creek. Small communities downstream add additional waste but this is insignificant compared to the Lockport area loadings. Lessening the diversion of canal water into the creek would create a major pollution problem in the creek from the canal to the mouth.

The Barge Canal, while not heavily polluted, is approaching a stage where continued organic loading will destroy its usefulness as a source of flow augmentation water for the many streams it normally supplies in the study area. Such watercourses as Eighteenmile Creek, Brockport Creek, Genesee River and Irondequoit Creek would suffer. Continued waste loadings will not only result in lowering the water quality of the canal itself, but will worsen pollution conditions in most of the receiving streams.

The section of the Barge Canal west of the Genesee River obtains most of its water from Lake Erie and discharges to streams along its 73 mile length. Industries in the western sector such as Upson Company at Lockport, Hunt Foods at Albion, and Duffy-Mott Company, Inc., at Holley, contribute a waste with a population equivalent of 324,000. The communities of Brighton, Henrietta, and Pittsford in Monroe County and Gasport in Niagara County discharge partially treated waste with a population equivalent of 6,800. The industries and communites are, as a result of inadequate treatment, steadily degrading canal water.

Inshore Waters and Small Streams

The inshore waters of Lake Ontario, except those areas surrounding stream and river mouths (Niagara River, Eighteenmile Creek, Genesee River, Irondequoit Bay, Oswego River, Salmon River, etc.) are in good bacterial condition. However, because of the high nutrient content, in Lake Ontario and tributaries, inshore waters of the Lake contain tremendous quantities of *Cladophora*. The algae eventually pile up on the shore and cause untold damages, economically and esthetically.

Pollution of inshore waters is unaffected by lakeside communities and industry with two major exceptions. These are the City of Rochester, already discussed, and the Hammermill Paper Company at Oswego. The paper company discharges waste with a population equivalent of 24,600 directly to Lake Ontario. (See Plate 6.) Foam and color

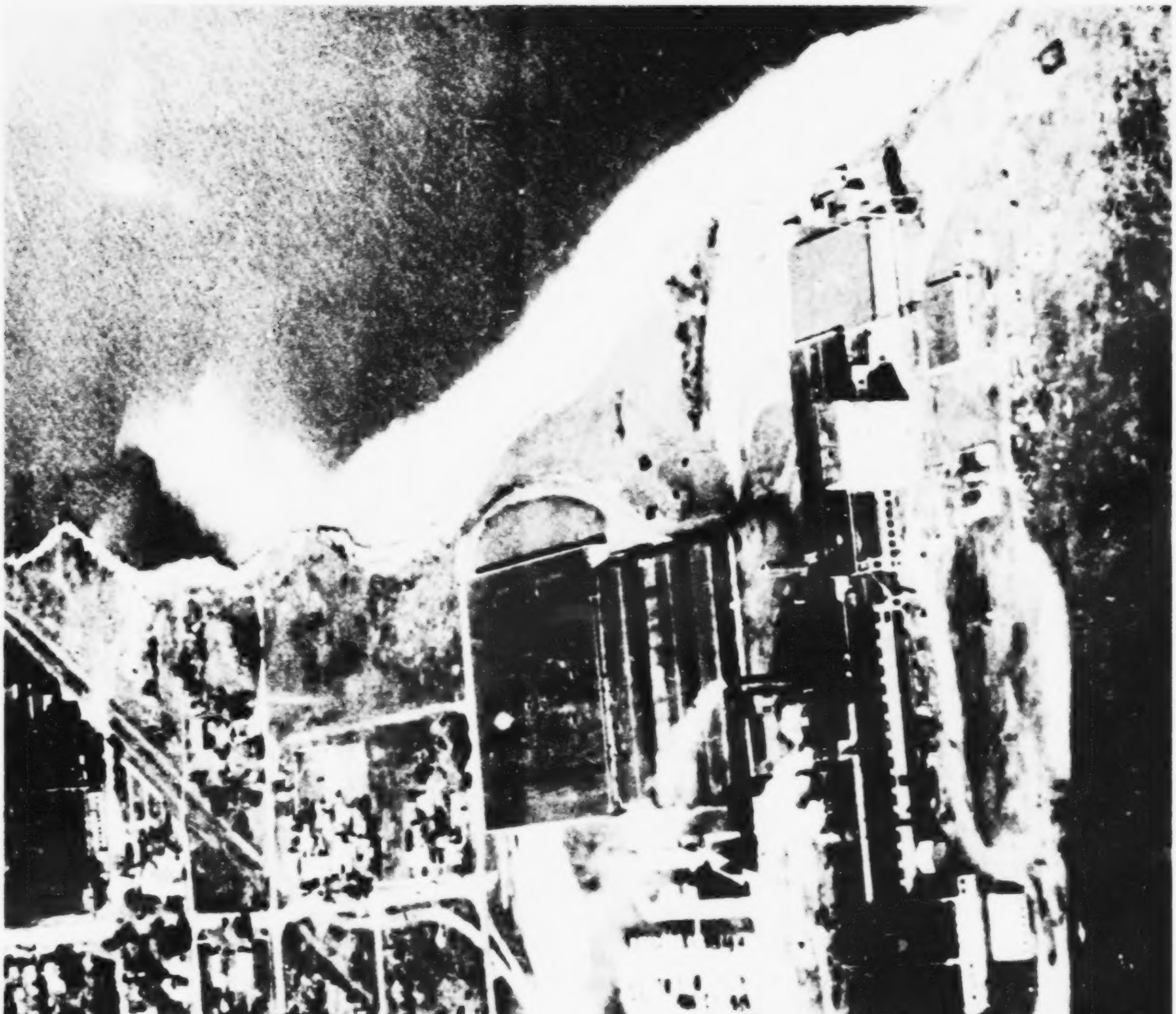


PLATE NO. 6 - Waste from Hammermill Paper Company entering Lake Ontario east of Oswego, New York. The point of discharge is the top right-hand corner of the picture. The plume, extending in a southwesterly direction, typifies the periodic reversals of currents along the southern lakeshore from the normal direction of flow toward the north and east.

from the paper mill are the causes of esthetically undesirable conditions.

Some 27 food-processing plants discharge partially treated wastes that adversely affect portions of many small streams in Orleans and Wayne Counties. Some of the major known polluters are: the Dairymen's League Co-op. Association, Inc., Adams, discharging a waste with a population equivalent of 3,000 to Sandy Creek; Borden's Dairy Farm Products Co-op., Inc., Mexico, 13,800 PE to Little Salmon River; and Duffy-Mott Company, Inc., Williamson, 61,800 PE to a tributary of Salmon Creek (West).

Good water quality in streams receiving water from the Barge Canal cannot be maintained in some instances without water from the Canal. The need for discharges from the Canal for flow augmentation is evident, and will continue and increase. Apportioning the available water in the Canal for other purposes may have a serious effect on receiving streams if water for the increasing flow augmentation needs is denied. Better waste treatment facilities on streams receiving canal water will lessen the need for canal water, but this will be offset by increased population and industrial growth in the future.

Wastes from Watercraft

Watercraft of all types are contributing untreated or inadequately treated wastes to the waters of the Lake Ontario Basin. Problems occur, or the potential therefor is greatest, in the commercial harbors and small boat marinas off the Lake, in the St. Lawrence Seaway, in the Barge Canal and in the Finger Lakes area.

Some 7,000 commercial ship passages are made through the St. Lawrence Seaway and across Lake Ontario each year. About 1,000 of these enter New York State's commercial ports from Rochester to Massena. About 750 commercial barges and their tugs use the Barge Canal each season.

Additional waste contribution from watercraft to Lake Ontario and waters of the State comes from pleasure boaters. Approximately 3,100 recreational watercraft can be accommodated at nine recreational harbors constructed by the Corps of Engineers along the lakeshore. It is estimated private moorings exceed this figure. The widespread distribution of the waste is reflected in the freedom of access of boats to most bodies of water in the Basin. There are some 65 publicly-operated boat ramps in the Basin, and many more under private care. The Barge Canal, for instance, has been known to accommodate about 30,000 boaters in one season. Oneida Lake, it is reported, experienced some 5,000 boats in one day. These two examples are duplicated in many areas of the Basin. From sheer numbers it can be visualized that boats can create a water pollution problem or contribute in an overall manner so as to upset nature's balance.

New York State, recognizing the problem of watercraft pollution passed a new law to deal with sewage and litter. When the law becomes effective, watercraft must have toilets equipped with pollution control devices to prevent the discharge of untreated human waste into the water. The Ontario Water Commission of Canada has also enacted a similar law. The United States Congress, if it adopts the recommendations of the Federal Water Pollution Control Administration's report, will also provide an effective means of controlling pollution from watercraft. (11)

Oil Pollution

The lack of major oil producers or users other than in the Niagara area has minimized the oil pollution problem in the Lake Ontario Basin. However, with major shipping taking place on Lake Ontario and in the Rochester Harbor, the Barge Canal being used as a prime means of transporting oil, oil pipelines crisscrossing the area, and the ever-increasing number of oil storage tank farms along the Barge Canal there is always the possibility of a disastrous oil spill.

In the last few years minor spills have been noted on the Barge Canal, Genesee River and Irondequoit Bay. In 1963 the New York State Department of Health in its study of the St. Lawrence River observed the deleterious effect of oil on wildlife. The oil came from commercial shipping and recreational boating. In 1961, ballast discharged from tankers in the St. Lawrence Seaway also caused problems along the shore, and on one occasion the temporary closing of Grassy Point Beach near the Thousand Island Bridge.

In the Niagara area, one of the major problems results from the accumulation of oil on the Buffalo River. Flushing action causes the heavy accumulations of oil to be discharged periodically to the Niagara River. Significant sources of oil to the Niagara River, other than that coming from the Buffalo River and the accidental spills, do not immediately appear on the water surface, but are first noticed when large oil films collect at various protected shore areas such as coves and marinas. In many cases there is no apparent relationship between the location of these oil concentrations and either the presence of known oil waste discharges or observable oil films on the water immediately upstream. Also, municipal waste treatment plants in the area do not seem to create observable oil films on the stream below their outfalls. However, tests have shown that the quantity of oil or extractables in the effluents of the sewage plants discharging directly to the upper Niagara River is over 32,000 lbs/day. (10)

The quantity of extractables in industrial effluents discharged in the Lackawanna-Buffalo area and direct to the Niagara River for which current data are available, is approximately 38,000 lbs/day. Discharges from some other industrial sources for which quantitative data have not as yet been made available are estimated to contribute an additional 5,000 lbs/day.

Oils probably cause more obvious damage to current uses of the Niagara River than any other single pollutant. Accidental spills of oil which create unusually heavy oil films on the Niagara River do occur, but improved precautionary measures have tended to reduce the incidence of such spills.

The Buffalo River is nearly always coated with oil. The principal known sources of these oils are the Pennsylvania Railroad shops, Mobil Oil Refinery, Donner-Hanna Coke plant and the Republic Steel Corporation.

At times of major oil spills from United States sources or flushouts of the Buffalo River, there may be an oil film along the entire United States shoreline down to Niagara Falls. At the falls it is mixed throughout the river creating a visible film over the entire lower Niagara.

There is also an oil film present in a limited area out from the Chevrolet plant at river mileage 32.0. Another observable oil film is present for some distance along the United States shore downstream from the Ashland Oil Refinery outfall at mileage point 28.9.

In the case of large oil spills to the Niagara, the oils frequently enter marinas in quantity, resulting in significant costs for the cleaning of boats. They have also made a private beach area on the east shore of Grand Island unusable for swimming for periods of time, as well as creating disagreeable coatings along the shore of other areas frequented by the public.

In addition to the damages of oil to boating and other recreational uses, evidence indicates that it is regularly killing ducks on the river. The Niagara River is a wintering area for certain ducks including the diving ducks, such as greater scaup and canvasbacks. These ducks usually come into this area early in December and remain in the river except during the more mild and quiet weather periods when they may go out into Lake Ontario. It appears that many of the ducks swim into the pellets of congealed oil or grease. The resultant oil or grease spot on their feathers breaks down their natural waterproofing and they die of body exposure to cold water or drowning. The presence of oil in the duck-inhabited areas and the incidence of oiled ducks do not appear to be related to unusual oil spills to the river, but to the waste oil and fat regularly discharged to the river. (See Plate 7.)

Disposal of Dredged Material

Lake Ontario has three deep-draft harbors that are dredged annually by the Corps of Engineers. These harbors at Rochester, Great Sodus Bay and Oswego, accommodate about 1,000 ships each year.

PLATE NO. 7 - Badly oiled duck climbing onto ice floe. Bird died less than an hour after being found. (Photo courtesy Mr. John Long.)

The Great Sodus Bay dredging operation involves some 6,000 feet of approach channel. The material in the channel is mostly from the Lake, is clean and has not posed a pollution problem when redeposited over a designated spoil area in the Lake.

The Rochester Harbor dredging operation involves about five miles of channel and two turning basins. Soil erosion upstream on the Genesee River tributaries contributes to silting of the harbor area. Industrial wastes, combined sewer overflows, and municipal waste combine with the silt to produce a highly organic bottom material. Tubificid worm population in the dredged area ranges from 6,500 to 29,000 per square meter. COD's of 1,330 to 4,200 mg/l have been found in the dredged material.

The overflow from the hydraulic dredge when in operation continually upsets the balance in the river. The wastewater discharged is high in organic matter and the fine suspended material is relatively hard to settle out. This redistribution of the waste in the confines of the river has an oxygen-demanding effect.

When the dredged material is deposited in the open area of the embayment over a designated spoil area, aerial photographs show the fine material is not readily settleable and is carried about the embayment by the currents.

A similar dredging operation in 1967 at Oswego Harbor of an area not usually dredged produced samples with COD ranging from 9,200 to 24,000 mg/l. The dredged material was then redeposited over a designated spoil area in Lake Ontario. (See Plate 8.)

Pesticides

Pesticides, improperly applied, can cause mass death of fish and cause insidious damage to the reproduction capability of mammals, fish and birds.

One of the best known ingredients of the synthetic organic pesticides is DDT. It is part of the family of chlorinated hydrocarbon chemicals which are stable, persistent and travel great distances. Residues from this type of pesticide, which has only seen extensive use since World War II have been found in penguins and crab seals as far away as Antarctica.

The danger from such pesticides lies not only in deaths directly attributable to them, but in the more subtle or indirect effect which may result from pesticide injection into the food chain. Food chains in the aquatic environment are especially vulnerable because they are exposed to land runoff carrying pesticides, in addition to those sprayed on them directly.

Traces of DDT have been found in fish taken from Cayuga and Skaneateles Lakes in the Oswego River Basin. The Lake Plain area which parallels the southern shoreline of Lake Ontario is an extensive fruit growing belt which utilizes enormous quantities of pesticides. In 1965, a pesticide analysis indicated that trace amounts of DDE and both isomers of DDT (chlorinated hydrocarbon pesticides) were present.

On both East Koy and Wiscoy Creeks in the Genesee River Basin, there have been several incidents of large fish kills attributable to an organic phosphate pesticide commonly used by potato growers in this area. Sampling results showed the presence of pesticides with higher concentrations present in the bottom samples. This was undoubtedly due to the two-week time lapse between interjection of the pesticide and sample collection.

Further research is urgently needed on these synthetic pesticides, their effect on plants and animals, and their ultimate impact on man. Enough is known, however, to make clear the need for closer control over pesticide usage. As a start, what is needed is a permit and accountability system yielding information on the kinds, amounts, and places of pesticide application.

Land Runoff

In addition to pollution from point sources, such as municipal and industrial wastewater discharge points and watercraft, much

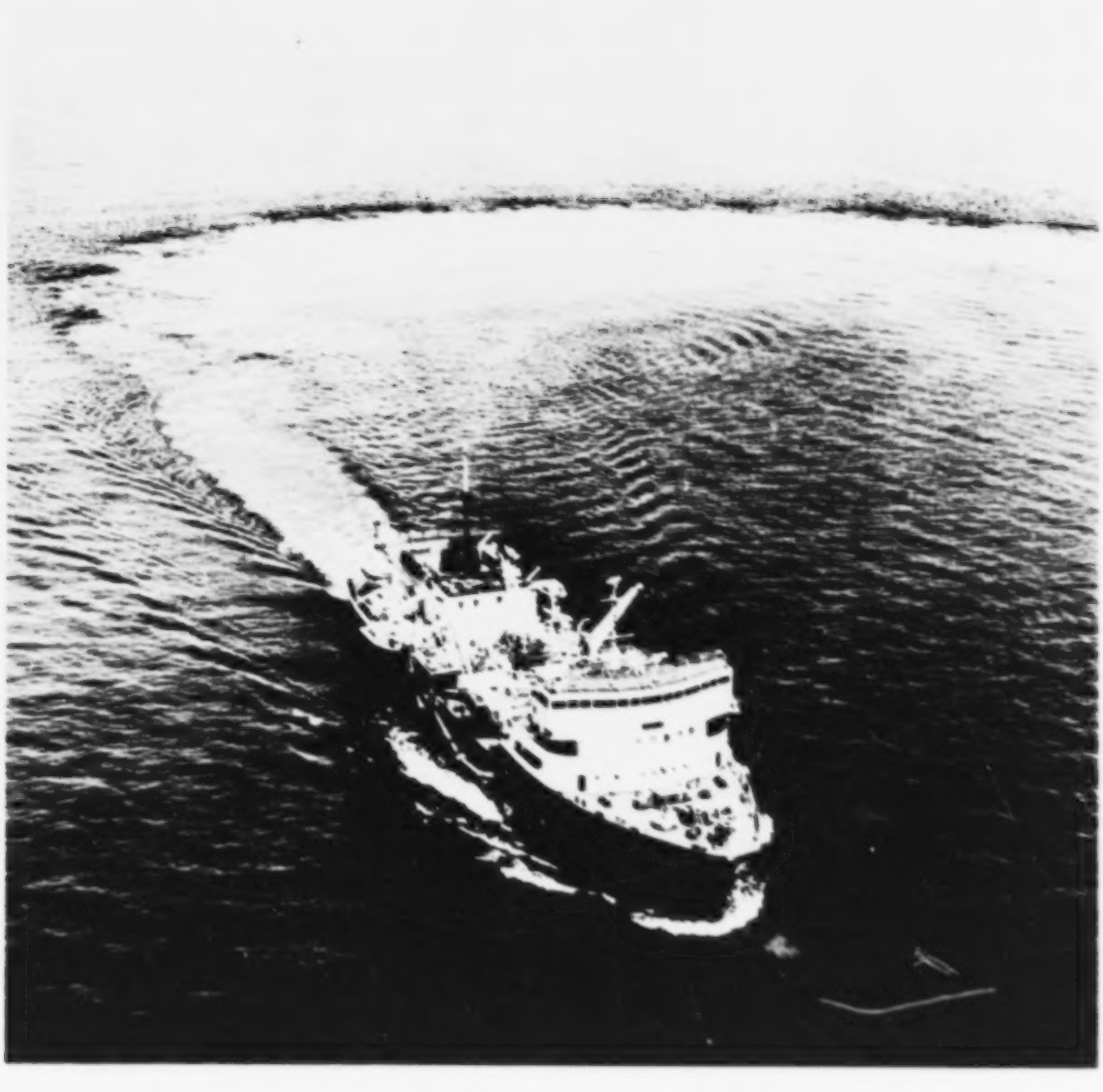


PLATE NO. 8 - Corps of Engineers dredge dumping Genesee River dredgings in Lake Ontario.

detrimental material gets into streams and lakes from non-point sources. These sources include: the runoff from rural and urban land; erosion products stemming from earth-moving work in the construction of subdivisions and highways; and residues from the application of chemicals, fertilizers, pesticides, and de-icing compounds used on streets. Runoff water will contain both dissolved impurities and suspended particulate matter, and both kinds have detrimental effects on the receiving waters.

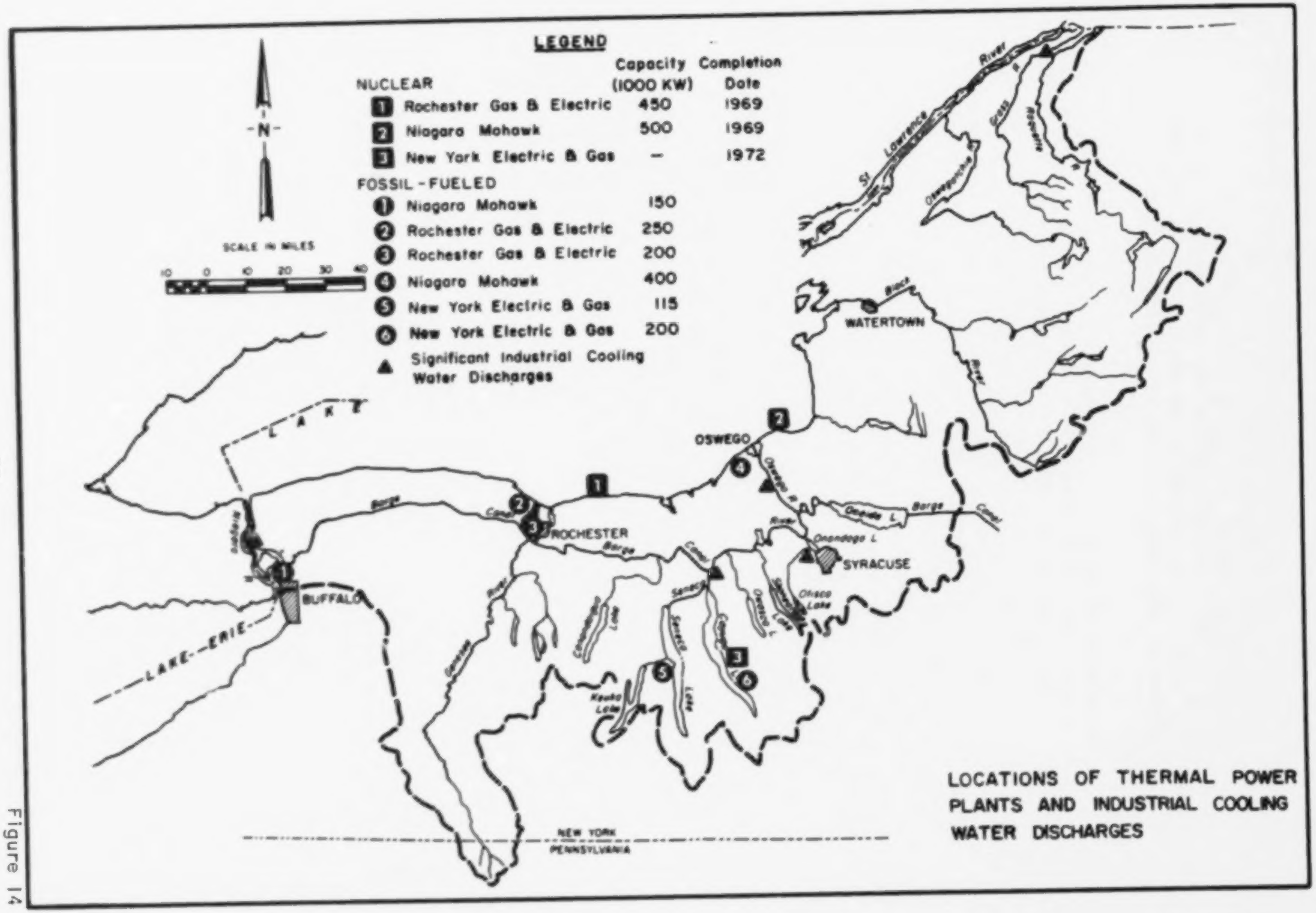
Suspended matter carried by flowing water will settle out in more quiescent waters with obvious physical damages. Sedimentation reduces the usable volume of water storage reservoirs; obstructs the channels of commercial and recreational waterways; blankets fish spawning beds in a manner that is frequently detrimental to propogation; and interferes with maintenance of the colonies of bottom-dwelling organisms which form a part of the food chain in aquatic life. The effects of sedimentation are almost, but not quite, all bad. An exception is, the geologic sedimentation process is what creates the wetlands which are a desirable habitat for waterfowl.

Not so obvious as physical damage are the chemical effects of sedimentation. Phosphate compounds, unlike the other typical constituents of fertilizer, are not easily leached out of soil, but rather tend to cling to (be adsorbed on) soil particles. The same is true for many types of pesticides, notably DDT and Dieldrin. It is in this manner that pesticides are accumulating in stream sediments, are taken up by the bottom-dwelling worms that ingest this mud, and from there eventually reach the top of the food chain in fish--and from there get to man. It will be seen that this whole chain of events can be interrupted at the start by good soil erosion preventive practices.

Although much has been done to improve soil conservation, a more intensified effort is needed--and the need is heightened by trends in agricultural practice toward increased application of fertilizers and pesticides. The soil conservationist and the water quality manager thus have a common goal; the one to keep soil on the land where it is beneficial, and the other to keep it out of the water environment where it is harmful.

Thermal Pollution

Power plants and industries using large quantities of cooling water are of concern to water quality because of the enormous quantities of waste heat they discharge to streams and lakes. The majority of existing installations wasting large quantities of heat are located on Lake Ontario and the inland lakes; the remaining significant sources of thermal pollution are located on the St. Lawrence, Oswego, Seneca, Genesee, and Niagara Rivers (see Figure 14). Nearing



-N-
SCALE IN MILES
10 0 10 20 30 40
LAKE
LAKE--ERIE
Niagara
BUFFALO
Barge
Canal
ROCHESTER
OSWEGO
SYRACUSE
WATERTOWN
Oswego R.
River
Oneida L.
Onondaga L.
Seneca
Seneca Lake
Cayuga Lake
Owasco L.
Skaneateles Lake
Otisco Lake
Keuka Lake
Canandaigua Lake
Genesee River
St. Lawrence River
Oswegatchie
Grass R.
Raquette R.
Black River
NEW YORK
PENNSYLVANIA

LEGEND

	Capacity (1000 KW)	Completion Date
NUCLEAR		
1 Rochester Gas & Electric	450	1969
2 Niagara Mohawk	500	1969
3 New York Electric & Gas	—	1972
FOSSIL-FUELED		
❶ Niagara Mohawk	150	
❷ Rochester Gas & Electric	250	
❸ Rochester Gas & Electric	200	
❹ Niagara Mohawk	400	
❺ New York Electric & Gas	115	
❻ New York Electric & Gas	200	
▲ Significant Industrial Cooling Water Discharges		

LOCATIONS OF THERMAL POWER PLANTS AND INDUSTRIAL COOLING WATER DISCHARGES

Figure 14

completion or in the planning stage are the first three nuclear-fueled power plants to be located in the Basin. Two are on Lake Ontario (Rochester and Oswego) and the other on Cayuga Lake (Lansing).

The effects of the present discharges of waste heat to Lakes Ontario, Seneca, and Cayuga appear to be minimal. These large bodies of water are better suited for dissipating large quantities of heat than are stream sectors. Fossil-fueled plants waste on the average about 1.5 units of heat for each equivalent unit of useful energy output; a nuclear-fueled power plant wastes, for a comparable output, about 2.25 units of heat energy. Heat from industrial cooling varies widely depending upon processes involved.

Heat added to a large lake produces two effects: 1) it creates a local zone of water warmer than the natural background temperature, and 2) it may warm the whole body of lake water and the air above it. Regarding the second effect, the critical body of water would be that contained in the epilimnion (upper layer) of a lake and the critical period would be in the summer months when water and air temperatures are warmest and stratification inhibits the dispersal of the input heat to a greater volume of lake water. In Lake Ontario the combined effect of existing plants plus the proposed nuclear-fueled plants was calculated to be imperceptible. In Cayuga and Seneca Lakes the effect of waste heat from existing and proposed plants was estimated to have little effect on the overall lake temperatures, and even this minute increase in summer water temperature would be nullified during the following winter. Onondaga Lake, however, with its relatively small volume, has a limited capacity to dissipate heat and could not be utilized to any great extent beyond the present total 100 MGD usage by Allied Chemical Company and Crucible Steel.

The first effect cited--the creation of a local zone of warm water--can be a serious problem in that an over-growth of algae may be stimulated in the vicinity of the outfall when other favorable conditions, such as a suitable lake bottom and supply of nutrients, are present. In a typical power plant installation, as the cooling water flows through the plant, its temperature is increased 10 to 20 degrees F. The local warm water zone may thus have a peak temperature some 10 to 20 degrees warmer than the background temperature. Some of the plant's waste heat will be transmitted to the ambient air; the rest will transfer into this local warm water zone by a combination of dilution and convection until the local water temperature merges with and becomes indistinguishable from that of neighboring waters. On occasions the used cooling water could conceivably return to the Lake at a colder temperature than the shoreline waters because of the existence of a sharp temperature gradient in the Lake between the points of intake and discharge. In any case, proper engineering of intake and outfall structures can insure that local warming effects will be minimized.

Streams do not have the capacity in general for dissipating waste heat that larger lakes possess. The selection of sites for future electric power plants is expected to depend heavily, not only on whether there is a good supply of low-temperature water, but whether the capacity of the receiving stream is adequate to dissipate the waste heat generated.

Chapter 4

IMPROVEMENT NEEDS

Water Quality Standards

A basic requirement for the successful management of water quality is the description in measurable terms of the quality needed to support desired water uses. In the waters covered by this report the necessary quality has been established in accordance with Federal and State statutes, and official standards, embodying appropriate criteria, are a matter of public record.

All waters of the State of New York have been classified in accordance with "Rules and Classifications and Standards of Quality and Purity" which were promulgated and adopted in accordance with Article 12 of the Public Health Law. Classification is based on a system of best usage ranging from Class "AA" (source of supply for drinking, culinary or food processing purposes and any other uses) to Class "D" (agricultural, or source of industrial cooling or process water supply and any other usage except for fishing, bathing or as source of supply for drinking, culinary or food processing purposes). Although lower classes were permitted in previous years, recent re-classification proceedings have resulted in establishing Class "D" as the lowest level of quality that is permitted at the present time.

The Federal Water Quality Act of 1965 required development of proposed water quality standards for the Niagara River, Lake Ontario, the St. Lawrence River and the Genesee River. The State of New York submitted proposed standards for these waters prior to July 1, 1967. The official state classifications were the basis of the proposal. These were supplemented with additional criteria provisions to meet the guidelines for Federal standards. The proposed standards as modified, were approved in August 1967 by the Secretary of the Interior.

Additional details on water uses, water quality goals and standards are available in the separate program reports referred to in Chapter 1. Although the Federal-State standards for the interstate waters and the state classifications for intrastate waters are the present legal basis for managing water quality, it should be recognized there will be need for re-examination and possible revision of standards to meet expanding and changing needs. Further, the lack of adequate knowledge about quality requirements for various uses has resulted in a very limited range of criteria in present standards. As research finds more suitable and complete criteria, it becomes essential for control agencies to modernize standards accordingly.

As an example, it is believed that quality requirements for Class "D" waters provide for little or no enhancement of the quality or value of waters. A desirable and realistic goal would be the upgrading of all waters to Class "C" or better within the next few years, no later than ten years at the most.

Municipal and Industrial Waste

The most pressing improvement need in the Lake Ontario Basin is the construction of waste treatment facilities by both municipalities and industries. Municipal waste treatment must reach a minimum level of secondary treatment, generally regarded as 85 percent or better reduction of biochemical oxygen demand. New York State has undertaken an ambitious construction program that should bring most municipal wastes up to this degree of treatment by 1972. With the aid of a billion-dollar bond issue voted in 1965, the State is currently financing 30 percent of the cost of new or remodeled sewage treatment plants and intercepting sewers. The State also prefinances an additional 30 percent of the cost of these facilities where projects are eligible for Federal grants but Federal money is not immediately available.

Table 4 summarizes the basin-wide treatment needs. The greatest municipal treatment need is the construction of secondary facilities where there are at present only primary plants. The total number of communities in the Basin that must upgrade their treatment to secondary or enlarge existing secondary plants is 88, but the population served by these communities is about 2.1 million, or 85 percent of the total population served.

Industrial waste treatment needs are enormous. Only a few dozen of the more than 200 industries known to have separate discharges (not discharging to a municipal collection system) have waste treatment facilities. Only one of 21 paper mills, Newton Falls Paper Company, treats its wastewater; only one of the more than 20 industries on the Niagara River, General Motors Chevrolet Division, has abated pollution. Food processors throughout the Basin urgently need to install biological treatment facilities.

Tables 5 through 9 contain a listing of estimated treatment needs for each identified waste producer. However, as there is considerable variation in the relative urgency of these, inclusion in these lists is not an automatic indication of current intensive action by the pollution control agencies. Each of these needs is indexed to accompanying location maps, Figures 15 through 19.

TABLE 4

LAKE ONTARIO AND U. S. ST. LAWRENCE RIVER BASINS
SUMMARY OF MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

Type of Treatment Needed	Total Population Served	Number
MUNICIPAL		
Primary and secondary	266,000	130
Upgrading to secondary or enlargement of secondary	2,060,000	88
Advanced waste treatment (high organic removal)	84,000	11
Totals	2,410,000	229

Type of Treatment Needed	Wasteflow (MGD)	Number
INDUSTRIAL		
Biological	224	136
Non-biological	286	64
Totals	510	200

TABLE 5

NIAGARA RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered	Estimated Needs					Map Index No. (Fig. 15)
		Sewers	Pri	Sec	Enlg	Adv	
Akron	2,840					x	5
Alden	2,040				x		8
Amherst S.D. #1	59,000				x		10
Attica	2,760					x	7
Batavia	18,200					x	6
Buffalo	600,000			x			12
Cheektowaga S.D. #5	65,000				x		11
(or connect to City of Buffalo Metropolitan System as proposed)							
Clarence		x	x	x			5
Grand Island	3,500			x			4
Lewiston	3,000			x			1
Niagara Falls	90,800		x	x			2
North Tonawanda	30,000			x			13
Tonawanda (T)	130,000			x			13
Tonawanda (City)	22,000			x			13
Youngstown	1,850			x			1

Key to Abbreviations
Pri - Primary
Sec - Secondary
Enlg - Enlargement
Adv - Advance
Biolog - Biological

TABLE 5 (Continued)

NIAGARA RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

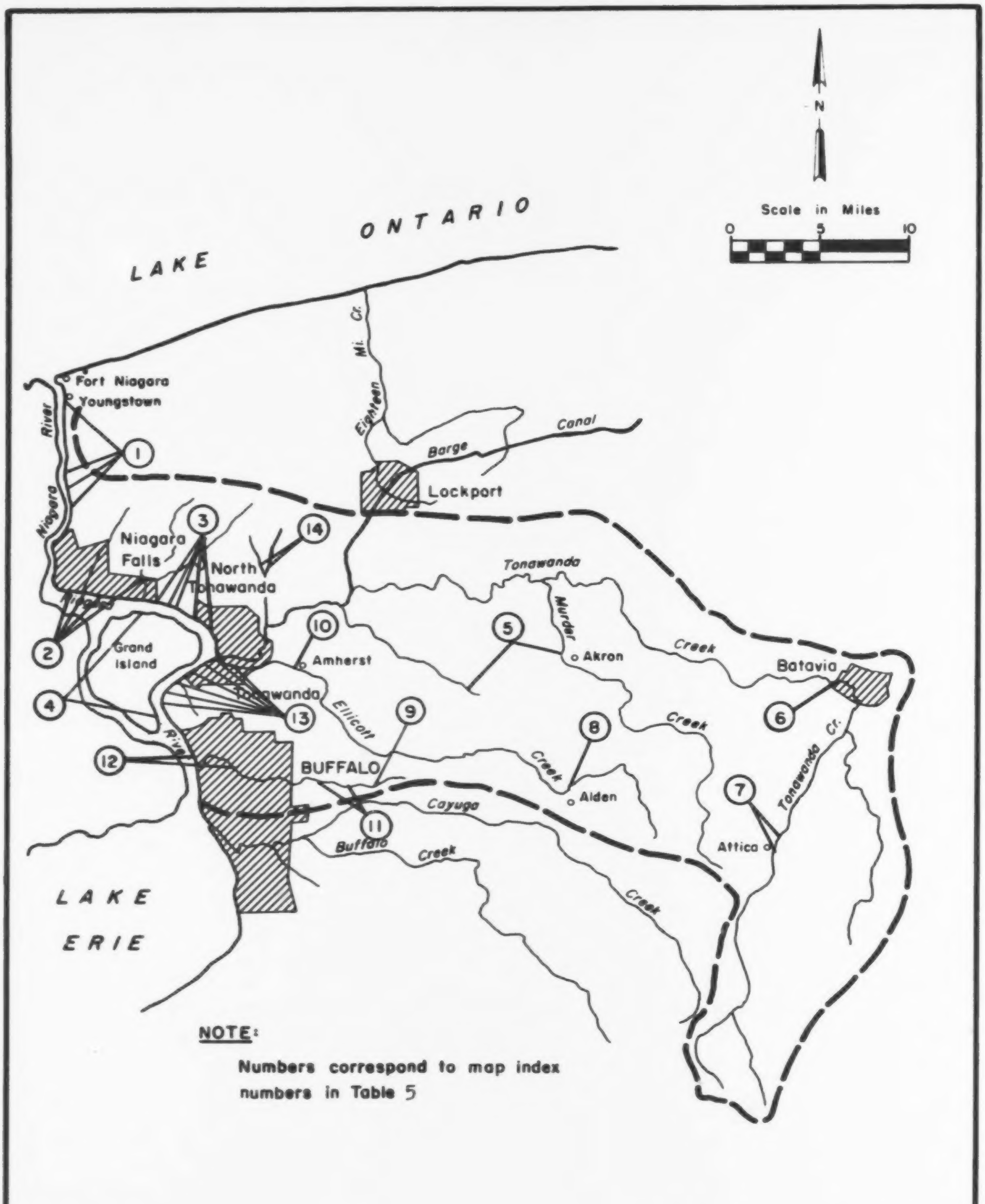
Industry Location	Waste Flow (MGD)	Estimated Needs			Map Index No. (Fig. 15)
		Settling	Biolog	Other	
Allied Chemical Corp., Semet-Solvay Division Tonawanda	5.5	x		Reduction of Phenols	13
Ashland Oil Corp. Tonawanda	47.5			Enlg of treatment for Phenols and oils	13
Carborundum Corp. Niagara Falls	2.4	x		Neutralization	2
Carborundum Metals Climax Akron	0.5			Reduction of toxic materials	5
Columbus McKinnon Corp. Tonawanda	0.10			Control of toxic materials	13
Continental Can Co. Tonawanda	3.0	x	x		13
E. I. duPont deNemours					
Electrochemicals Div. Niagara Falls	32.4	x	x	Reduction of oils; neutralization	2
Film Division Tonawanda	8.3	x	x	Neutralization	13
Ford Ball Gum Co. Akron			x		5
Hooker Chemical Corp.					
Durez Division North Tonawanda	3.3	not determined			3
Electrochemicals Div. Niagara Falls	23.6	x	x	Reduction of oils and Phenols	3
International Paper Co. North Tonawanda	9.4	x	x	Immed. control of digest. liquors	3

TABLE 5 (Continued)

NIAGARA RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	 Biolog	 Other	Map Index No. (Fig. 15)
National Lead Corp. Batavia				Control of toxic materials	6
Olin-Mathieson Chem. Corp. Niagara Falls		x			2
Pratt and Letchworth Buffalo	0.03			Connect to Buffalo System as proposed	12
Spaulding Fibre Co. Tonawanda	4.4	x	x		13
Stauffer Chemical Corp. Lewiston	2.0	x		Neutralization	1
Tonawanda Iron North Tonawanda	14.4	x			3
Union Carbide & Carbon Corp. Niagara Falls	31.7	x		Neutralization	3
Western Electric Tonawanda	1.2			Reduction of oils	13
Westinghouse Corp. Cheektowaga	1.4	x		Reduction of phenols	9
Wurlitzer Corp. North Tonawanda		not determined			14


LAKE ONTARIO
Scale in Miles
0 5 10
N
Fort Niagara
Youngstown
Niagara River
Eighteen Mi. Cr.
Barge Canal
Lockport
Niagara Falls
North Tonawanda
Tonawanda Creek
Murder Creek
Akron
Batavia
Amherst
Grand Island
Tonawanda
Ellicott Creek
BUFFALO
Alden
Attica
Tonawanda Cr.
Cayuga Creek
Buffalo Creek
LAKE ERIE
1
2
3
4
5
6
7
8
9
10
11
12
13
14

NOTE:

Numbers correspond to map index numbers in Table 5

MUNICIPAL & INDUSTRIAL
WASTE TREATMENT NEEDS
NIAGARA RIVER BASIN
(AS OF JUNE 1968)

Figure 15

TABLE 6

GENESEE RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs					Map Index No. (Fig. 16)
		Sewers	Pri	Sec	Enlg	Adv	
Andover	(1,250)	x	x	x			51
Angelica	(900)	x	x	x			48
Avon	2,770		x	x			25
Belfast	(800)	x	x	x			47
Belmont	(1,150)	x	x	x			49
Bergen	960		x	x			9
Caledonia	(1,900)	x	x	x			12
Canaseraga	(730)	x	x	x			38
Caneadea	(1,900)	x	x	x			46
Castile	(1,240)	x	x	x			43
Cuylerville	(500)	x	x	x			29
Churchville	(1,000)	x	x	x			8
Dalton	(750)	x	x	x			41
Dansville	5,460			x			35
East Avon	(650)	x	x	x			24
Gates-Chili-Ogden	25,000			x			7
Geneseo	3,280				x		30
Fillmore	(520)	x	x	x			45

TABLE 6 (Continued)

GENESEE RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs					Map Index No. (Fig. 16)
		Sewers	Pri	Sec	Enlg	Adv	
Friendship	(1,200)	x	x	x			54
Hemlock	(500)	x	x	x			22
Honoeye	(560)	x	x	x			21
Honoeye Falls	2,800				x	x	18
Houghton	(1,200)	x	x	x			46
Lakeville	(1,340)	x	x	x			26
LeRoy	4,800			x			13
Livonia	1,050					x	27
Mt. Morris	3,200			x			32
Mumford	(900)	x	x	x			11
Nunda	(1,200)	x	x	x		x	40
Pavilion	(540)	x	x	x			14
Perkinsville	(730)	x	x	x			36
Perry	4,500		x	x		x	42
Rush	(500)	x	x	x			17
Scio	(600)	x	x	x			50
Scottsville	2,000		x	x			10
Silver Lake	(630)	x	x	x			42
Silver Springs	(725)	x	x	x			43

TABLE 6 (Continued)

GENESEE RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs Sewers	Pri	Sec	Enlg	Adv	Map Index No. (Fig. 16)
Sonyea	500			x			39
Warsaw	3,650			x		x	16
Wayland	(2,000)	x	x	x		x	37
Wellsville	6,000			x			52
W. Bloomfield	(500)	x	x	x			20
Whitesville	(600)	x	x	x			53
Wyoming	(500)	x	x	x			15
York	300 (1,100)	x	x	x			28

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 16)
Ainsbrook Corp. Warsaw	0.04	x	x		16
Borden, Inc. Whitesville	0.16	x	x		53
Conesus Milk Prod. Co-op. Assn., Inc. Nunda	0.03	x	x		40

TABLE 6 (Continued)

GENESEE RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

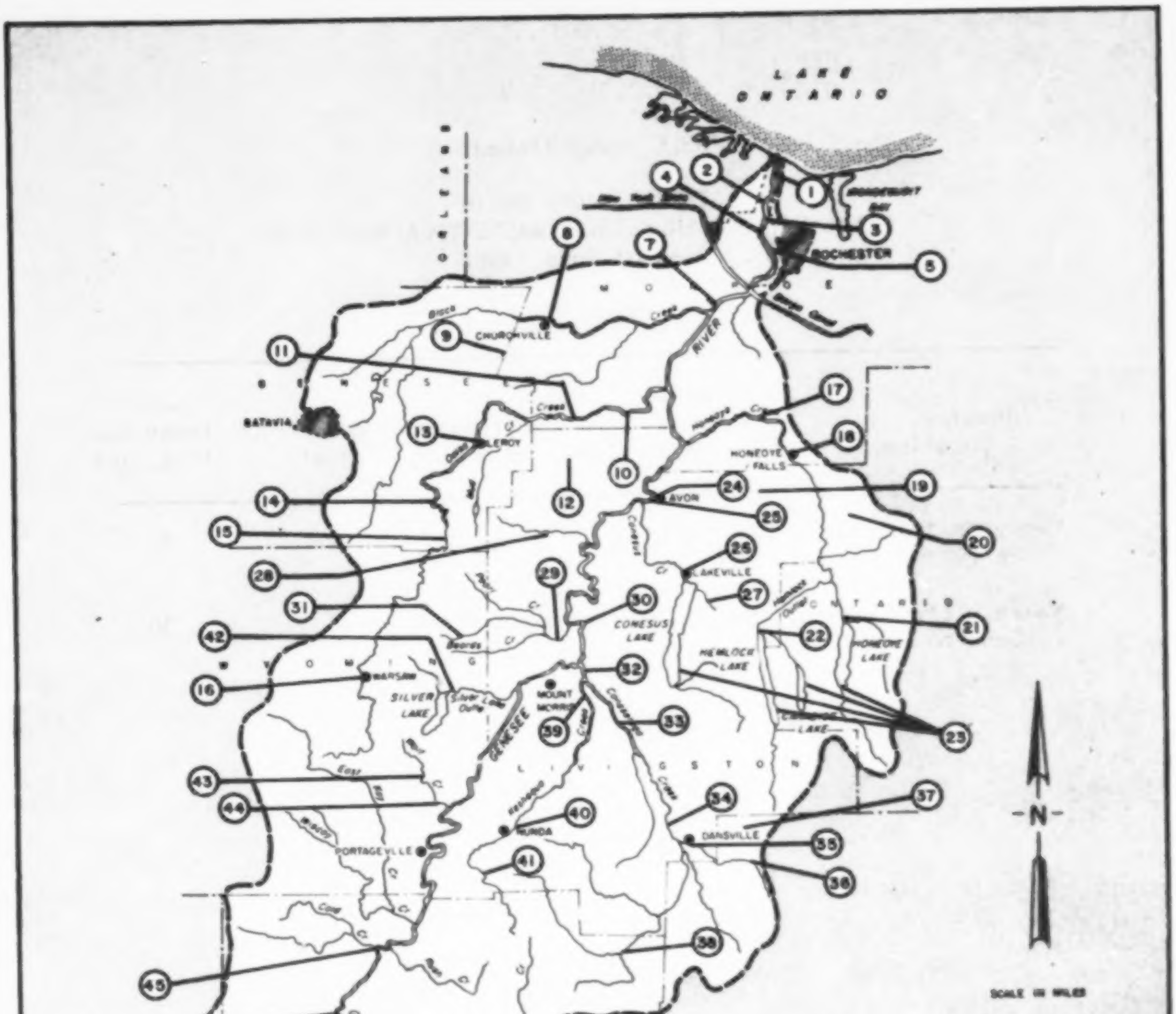
Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 16)
Curtice-Burns, Inc. Bergen	0.54			Control of spray irrigation runoff	9
Dairymen's League Co-op. Assn., Inc. Groveland	0.01	x	x		33
Eastman Kodak Co. Rochester	26.0		x	High organic removal	2
FMS & Swell Co. Perkinsville	0.01	x	x		36
Foster Wheeler Corp. Dansville	0.34	not determined			34
Friendship Dairies, Inc. Friendship	0.05	x	x		54
General Foods - Birds Eye Division Avon	1.0			Connect to municipal system	25
Lapp Insulator Co., Inc. LeRoy	0.14	x			13
LeRoy Elm Dairy, Inc. LeRoy	0.02	x	x	Connect to municipal system	13
Morton Salt Co. Silver Springs	0.02	x		Enlargement	43

TABLE 6 (Continued)

GENESEE RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 16)
Perry Knitting Co. Perry	0.13	x	x		42
Wallace and Tiernan, Inc. Geneseo	0.01	not determined			30


LAKE ONTARIO
IRONDEQUOIT BAY
ROCHESTER
ORLEANS
MONROE
GENESEE
BATAVIA
CHURCHVILLE
LEROY
HONEOYE FALLS
AVON
LAKEVILLE
CONESUS LAKE
HEMLOCK LAKE
HONEOYE LAKE
CANADICE LAKE
ONTARIO
WYOMING
WARSAW
SILVER LAKE
MOUNT MORRIS
LIVINGSTON
NUNDA
DANSVILLE
PORTAGEVILLE
GENESEE RIVER
CATTARAUGUS
ALLEGANY
STEUBEN
ANGELICA
SCIO
WELLSVILLE
NEW YORK
PENNSYLVANIA
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SCALE IN MILES
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NOTE:

Numbers correspond to map index numbers in Table 6

MUNICIPAL & INDUSTRIAL WASTE TREATMENT NEEDS

GENESEE RIVER BASIN
(AS OF JUNE 1968)

Figure 16

TABLE 7

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs					Map Index No. (Fig. 17)
		Sewers	Pri	Sec	Enlg	Adv	
Auburn	41,000			x		x	21
Aurora	900		x	x			18
Baldinsville	10,500			x			31
Brewerton	(1,000)	x	x	x			34
Bridgeport	(500)	x	x	x			44
Camden	2,400 (400)	x		x	x		41
Camillus	1,420			x			28
Cayuga	750			x			20
Cayuga Heights	4,500			x			17
Cazenovia	2,600		x	x			37
Chittenango	3,500			x			36
Cleveland	(730)	x	x	x			42
Clifton Springs	(1,950)	x	x	x			2
Clyde	1,300 (1,400)	x		x			14
Cold Springs	(540)	x	x	x			31
Collamer	(500)	x	x	x			44
Constantia	(800)	x	x	x			43
Dryden	(1,400)	x	x	x			26

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs Sewers	Pri	Sec	Enlg	Adv	Map Index No. (Fig. 17)
Dundee	1,470			x	x	x	8
Durhamville	(800)	x	x	x			38
Elbridge	(830)	x	x	x			22
Fayetteville	(4,500)	x	x	x		x	35
Fulton	14,000			x			32
Geneva	17,300			x			10
Gorham	(500)	x	x	x			4
Groton	2,500			x			25
Hammondsport	1,180		x	x			6
Jamesville	(1,000)	x	x	x			30
Jordan	1,380		x	x			22
Lee Center	(500)	x	x	x			40
Locke	(550)	x	x	x			24
Lyons	4,100				x		13
Macedon	(645)	x	x	x			11
Manchester	1,345			x			2
Manlius	2,000	Connect to new Sanitary District Plant at Fayetteville					35

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs					Map Index No. (Fig. 17)
		Sewers	Pri	Sec	Enlg	Adv	
Marcellus	4,500			x			27
Marion	(890)	x	x	x			11
Memphis	(500)	x	x	x			28
Minetto	(800)	x	x	x			33
Minoa	1,840			x			35
Moravia	1,500		x	x			24
Mottville	(600)	x	x	x			23
Naples	1,240		x	x			5
Nedrow	(2,000)	x	x	x			30
Newark	12,900				x		12
Newfield	(500)	x	x	x			17
North Bay	(600)	x	x	x			39
Odessa	(570)	x	x	x			9
Oneida	12,000			x			38
Onondaga	(1,500)	x	x	x			30
Onondaga County Treatment District							
Geddes	6,000				x		
Jamesville Penitentiary	600			x			
Ley Creek	74,500	Pump to expanded Metropolitan Plant					

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs Sewers	 Pri	 Sec	 Enlg	 Adv	Map Index No. (Fig. 17)
Onondaga County Treatment District (Continued)							
Meadowbrook	6,000	Connect to District Plant at Fayetteville					
Morgan Road	5,900			x			
Nine Mile	2,500			x			
Saw Mill Creek	2,000	Combine with District's Morgan Road Plant					
Syracuse Metro.	250,000			x			
Oswego							33
West Side	4,500			x			
East Side	8,900		x	x			
Ovid	(790)	x	x	x			16
Penn Yan	5,770				x		7
		Or excl. of inadequately pretreated industrial wastes					
Phelps	1,900				x		3
		Or excl. of inadequately pretreated industrial wastes					
Phoenix	2,000			x			32
Port Byron	300 (900)			x			21
Savannah	(600)	x	x	x			14
Seneca Falls	7,440			x			15
Seneca Knolls							29
S. D. #1	2,500			x			
S. D. #2	630			x			

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs					Map Index No. (Fig. 17)
		Sewers	Pri	Sec	Enlg	Adv	
Sherrill	3,800			x			38
Shortsville	1,380			x			2
Skaneateles	2,920			x			23
Skaneateles Falls	(625)	x	x	x			23
Sylvan Beach	(800)	x	x	x			39
Tully	800	x	x	x			30
Union Springs	1,065			x			19
Vernon	900			x			38
Verona	(500)	x	x	x			38
Victor	1,700				x		1
Wampsville	(560)	x	x	x			36
Warners	(700)	x	x	x			28
Waterloo	5,100			x			15
Watkins Glen	5,000			x			9
Weedsport	1,730		x	x			21

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	 Biolog	 Other	Map Index No. (Fig. 17)
Allied Chemical Co. Solvay Process Div. Solvay	110	x		Continue feasibility of connection to County Municipal System; enlarge settling facilities.	29
American Can Co. Geneva		not determined			10
American Locomotive Co. Auburn	0.001	x		Oil separation	21
Armstrong Cork Co., Inc. Fulton	4.22	x	x		32
Bloch & Guggenheimer, Inc.					
Leets Switch		x	x		4
Seneca Castle		x	x		3
Borden, Inc. Moravia	0.005	x	x		24
Breneman, Inc. Oswego	0.10	x	x	(or connect to new Municipal System)	33
Burrows Tissue Co. West Phoenix	2.30	x	x		31
Castle Kraut Co. Lyons		x	x	Enlarge Lagoons as needed	13
Columbia Mills, Inc. Minetto	0.49	x	x		33

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs			Map Index No. (Fig. 17)
		Settling	Biolog	Other	
Comstock Foods, Inc. Rushville	0.20	x	x	Enlarge lagoons as needed	4
Cooperdale Dairy, Inc. Skaneateles Falls	0.72	x	x		23
Cowles Chemical Co. Skaneateles Falls	0.935			Enlarge biolog. treatment; control toxic substances	23
Crawford Kraut Co.					
Palmyra		x	x		11
Port Gibson		x	x		12
Crouse-Hinds Co. Syracuse	0.72	x		Connect to Municipal System	29
Crucible Steel Corp. Town of Geddes	7.20	x		Neutralization and oil separation	29
Dairymen's League Co-op. Assoc., Inc.					
Cato	0.003	x	x		31
Vernon	0.15	x	x		38
Dewan Dairy, Inc. Oneida Castle	0.014	x	x	Enlarge lagoons as needed	38
Dilts Machine Works Div. Fulton		x			33
Edgett & Burnham Co., Inc. Newark	0.05	x	x	(or connect to expanded Municipal System)	12

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs			Map Index No. (Fig. 17)
		Settling	Biolog	Other	
Empire State Pickling Co.					
Geneva		x	x	Enlarge lagoons as needed	10
Gorham		x	x	" " " "	4
Shortsville	0.003	x	x	" " " "	2
Evans Chemetics Co.					
Geneva	0.007	not determined			10
Waterloo	3.25	x	x	Neutralization, removal of toxic substances	15
Filmore Co-op. Assoc., Inc. Moravia	0.003	x	x		24
Garlock Packing Co. Palmyra	1.30	x	x	Enlarge aerated lagoons	11
Geb-Souhan Mills Seneca Falls		not determined			15
Grandview Dairy Gorham		not determined			4
Greenwood Foods, Inc. Waterloo		x	x		15
H. C. Hemingway & Co. Clyde		x	x	Enlarge lagoons as needed	14
International Salt Co. Watkins Glen	14.5	x		Control of chlorides and ash waste	9

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 17)
Kordite Corp. Mobil Chemical Plastics Div. Macedon	0.47	not determined			11
Lakeland Farms, Inc. Dresden		x	x		7
Manchester Canning Co., Inc. Manchester		x	x	Enlarge lagoons as needed	2
Marion Canning Co. Marion	0.09	x	x	Enlarge lagoons as needed	2
McIntyre Bros.Paper Co. Fayetteville	1.28	x	x	Connect to new Limestone-Meadowbrook-Manlius S.D.	35
McIvor Kraut Co. McIvor Corners	0.07	x	x	Enlarge lagoons as needed	3
Mercury Aircraft Co.					
Dresden		not determined			7
Hammondsport		not determined			6
National Biscuit Co. Lyons	0.11	x	x		13
The Nestle Co., Inc. Fulton	0.25	x	x		32
North End Paper Co. Fulton	0.25	x	x	(or connect to new Municipal System)	32

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	 Biolog	 Other	Map Index No. (Fig. 17)
Nye-Wait Carpet Co. Auburn	0.012	not determined			21
Oneida-Madison Co-op. Assoc., Inc. Sherrill	0.04	x	x		38
Oswego Package Boiler Co. Oswego	0.03	not determined			33
Penn Central Railroad Manlius	.0025			Enlarge oil separation facilities	35
Perfection Canning, Inc. Newark	0.15	x	x	(or connect to expanded Municipal System)	12
Porritts & Spencer, Inc. Skaneateles	0.03	x	x	Enlarge lagoons as needed	23
D. W. Putnam Co., Inc. Hammondsport		x	x		6
Sealright Container Co., Inc. Fulton	4.00	x	x		32
Seneca Dairy Co. Watkins Glen		x	x		9
Seneca Knitting Mills Seneca Falls	0.23	x	x	(or connect to new Municipal System)	15

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

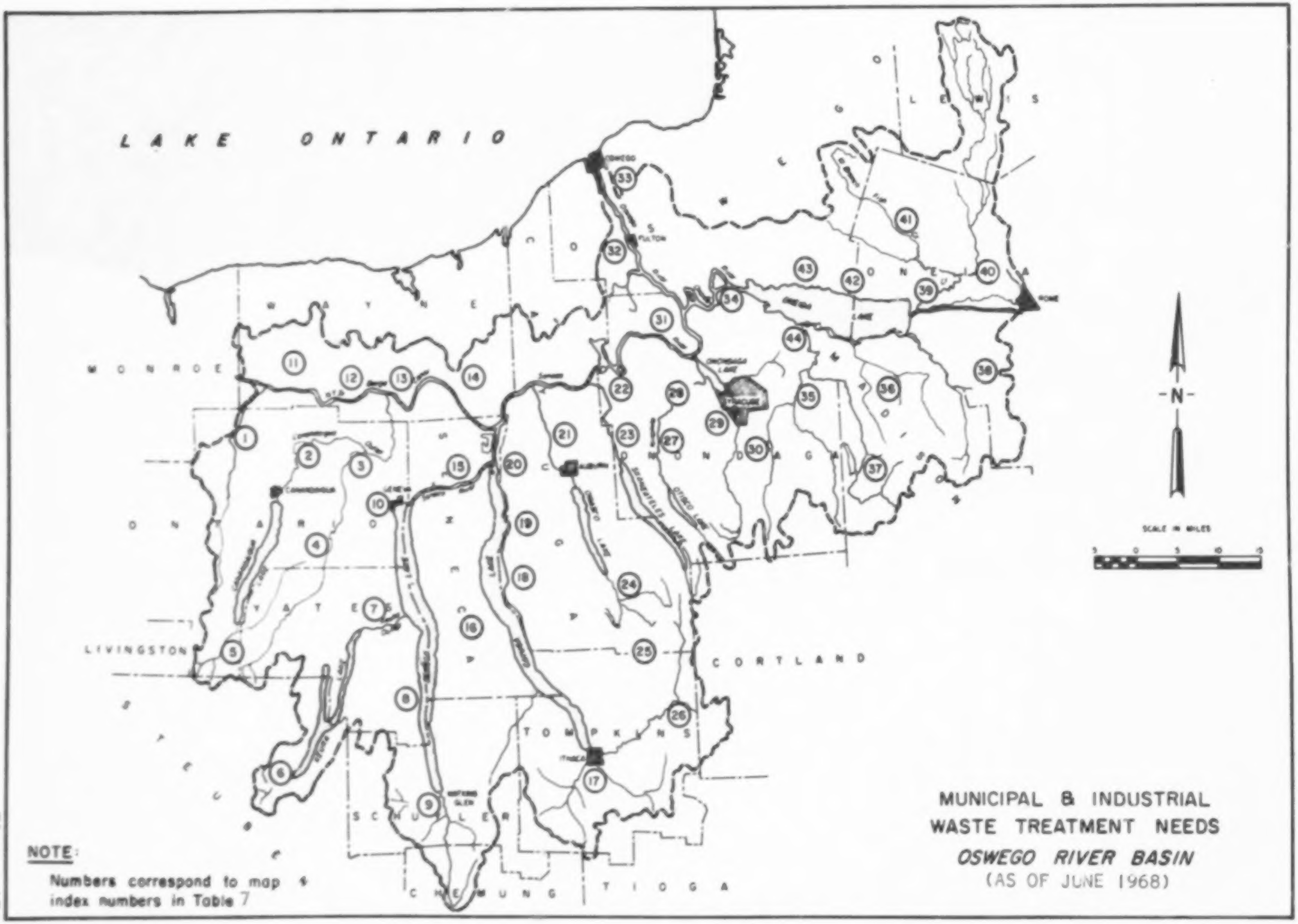
Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Estimated Needs Biolog	Estimated Needs Other	Map Index No. (Fig. 17)
Silverbrook Farms Camillus	0.014	x	x		28
Smith-Corona, Inc. Groton				Enlarge facilities for removal of toxic substances	25
Souhan Dairy Seneca Falls	0.05	x	x	(or connect to new Municipal System)	15
Suburban Park Amusement Corp. Manlius	0.95	x	x	(or connect to new treatment plant at Fayetteville)	35
Sylvania Electrical Products, Inc. Seneca Falls	0.89	x	x	(or connect to new Municipal Sewage System)	15
Taylor Wine Co. Rheims	0.24	x	x	Enlarge lagoons as needed	6
Transelco Co. Dresden		not determined			7
Victor Insulator Co. Victor	0.02	not determined			1
Watkins Salt Co. Watkins Glen				Control of chloride and ash discharges to Seneca Lake	9
Wayne County Produce Marion		x	x		11

TABLE 7 (Continued)

OSWEGO RIVER BASIN
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 17)
Welch-Allyn, Inc. Skaneateles Falls	0.027	x		Removal of toxic materials	23
White House Milk and Cream Co., Inc. Fenner	0.015	x	x		37
Widmer Wineries Naples		x	x	Enlarge lagoons as needed	5


LAKE ONTARIO
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OSWEGO
ONEIDA
LEWIS
ONONDAGA
MADISON
CAYUGA
SENECA
ONTARIO
YATES
LIVINGSTON
STEUBEN
SCHUYLER
CHEMUNG
TOMPKINS
TIOGA
CORTLAND
OSWEGO
FULTON
ROME
SYRACUSE
AUBURN
GENEVA
CANANDAIGUA
ITHACA
WATKINS GLEN
ONONDAGA LAKE
ONEIDA LAKE
OWASCO LAKE
SKANEATELES LAKE
OTISCO LAKE
SENECA LAKE
CAYUGA LAKE
KEUKA LAKE
CANANDAIGUA LAKE
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MUNICIPAL & INDUSTRIAL
WASTE TREATMENT NEEDS
OSWEGO RIVER BASIN
(AS OF JUNE 1968)

NOTE:
Numbers correspond to map & index numbers in Table 7

Figure 17

TABLE 8

BLACK-U.S. ST. LAWRENCE RIVER BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs Sewers	Pri	Sec	Enlg	Adv	Map Index No. (Fig. 18)
Alexandria Bay	2,500		x	x			18
Antwerp	500 (300)	x	x	x			18
Beaver Falls	(640)	x	x	x			25
Black River	(1,240)	x	x	x			22
Boonville	2,000 (400)			x			28
Brownville	500 (500)	x	x	x			21
Canton	5,100			x			10
Cape Vincent	1,000		x	x			5
Carthage	3,000 (1,215)	x	x	x			24
Chaumont	(525)	x	x	x			20
Clayton	2,500		x	x			5
Copenhagen	(670)	x	x	x			19
Croghan	275 (550)	x	x	x			25
Deferiet	700			x			23
Dexter	1,010		x	x			21
Edwards	150 (500)	x	x	x			12
Felts Mills	(550)	x	x	x			22
Glen Park	(560)	x	x	x			22

TABLE 8 (Continued)

BLACK-U.S. ST. LAWRENCE RIVER BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs Sewers	Pri	Sec	Enlg	Adv	Map Index No. (Fig. 18)
Great Bend	(500)	x	x	x			22
Gouverneur	4,800		x	x			15
Harrisville	500 (340)	x	x	x			17
Hermon	(610)	x	x	x			11
Heuvelton	(810)	x	x	x			3
Long Lake	(700)	x	x	x			30
Lowville	4,000			x			26
Lyons Falls	(890)	x	x	x			27
Madrid	800				x		8
Massena	15,785			x			6
Morristown	(500)	x	x	x			5
Natural Bridge	(500)	x	x	x			18
Newton Falls	(900)	x	x	x			13
Norfolk	1,340			x			7
Norwood	1,800		x	x			8
Ogdensburg	17,000			x			4
Old Forge	950			x			28
Philadelphia	600 (270)	x	x	x			18

TABLE 8 (Continued)

BLACK-U.S. ST. LAWRENCE RIVER BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)		Estimated Needs Sewers	Pri	Sec	Enlg	Adv	Map Index No. (Fig. 18)
Port Leyden	450	(450)	x		x			28
Potsdam	6,930			x	x			9
Redwood		(525)	x	x	x			18
Russell	380	(120)	x	x	x			11
S. Colton		(660)	x	x	x			29
Star Lake		(800)	x	x	x			13
Theresa		(960)	x	x	x			18
Tupper Lake	5,200				x			14
Waddington	920				x			2
Watertown	34,000				x			22
West Carthage	1,800	(400)	x	x	x			24

TABLE 8 (Continued)

BLACK-U.S. St. LAWRENCE RIVER BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs			Map Index No. (Fig. 18)
		Settling	Biolog	Other	
Aiello Dairy Farms Co. Heuvelton	2.24	x	x		3
Aluminum Co. of America Massena	20.5			Enlg. of oil separation and settling facilities	6
Borden, Inc. Pioneer Ice Cream Div. Gouverneur	0.30	x	x		15
Brownville Paper Co. Brownville	0.85	x	x		21
Carthage Paper Makers, Inc. W. Carthage	7.74	x	x	Immed. control of digest. liquors	24
Crown-Zellerback Co. Carthage	2.50	x	x	Immed. control of digest. liquors	24
DeKalb Dairy Co. DeKalb Junction	0.05	x	x		3
Diamond National Corp. Ogdensburg	4.0	x	x	Immed. removal of debarking wastes	4
Ed Green Dairy Co. Watertown	0.004			Connect to municipal system	22
Foremost Dairies New Bremen	0.03	x	x		26
Georgia Pacific Gould Division Lyons Falls	20.3	x	x	Immed. control of digest. liquors	27

TABLE 8 (Continued)

BLACK-U.S. ST. LAWRENCE RIVER BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

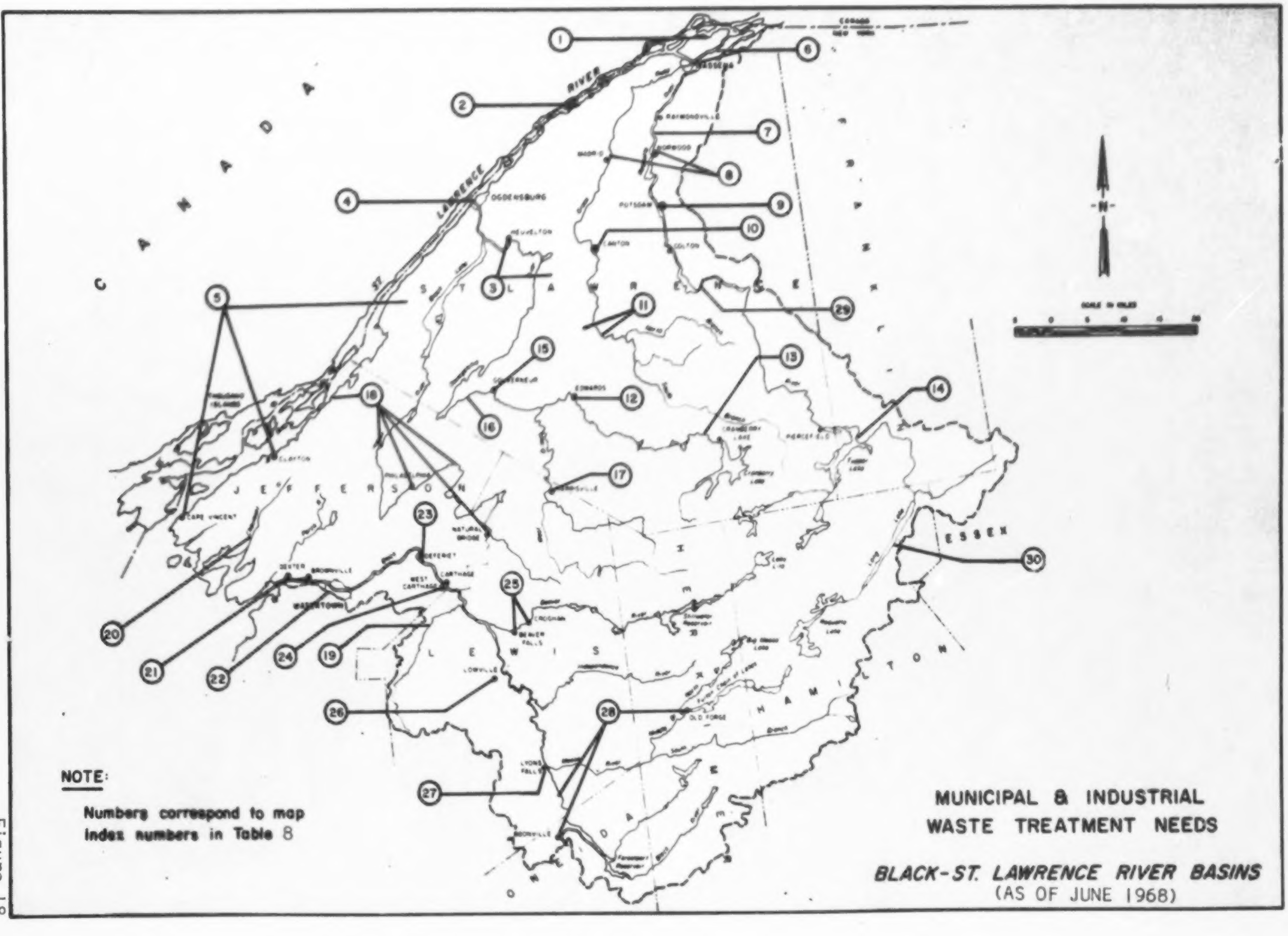
Industry Location	Waste Flow (MGD)	Estimated Needs Settling	 Biolog	 Other	Map Index No. (Fig. 18)
General Motors Corp. Chevrolet Division Massena	3.0			Enlg. of oil separation and settling facilities	1
Harrisville Dairy Harrisville	0.02	x	x		17
Knowlton Bros. Paper Co. Watertown	0.55	x	x	Immed. control of digest. liquors	22
Kraft Foods Canton	0.38			Connect to Municipal System	10
Latex Fiber Inds.,Inc. Beaver Falls	4.3	x	x		25
J. P. Lewis Paper Co. , Beaver Falls	2.8	x	x	Immed. control of digest.liquors	23
Brownville		x	x	" " " " "	21
Lowville Producers Dairy Co-op. Lowville	0.001			Connect to Village System	26
Nekoosa-Edwards Paper Co. Potsdam	1.14	x	x	Immed. control of digest. liquors	9
Newton Falls Paper Mill, Inc. Newton Falls	6.4			Enlg. of lagoons as needed	13
Northland Paper Co. Norfolk	5.0	x	x		7

TABLE 8 (Continued)

BLACK-U.S. ST. LAWRENCE RIVER BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 18)
Pahler Packing Corp. Potsdam	0.02	x	x		9
Paine and Jones Printing Co. Lowville	0.12			Connect to Municipal System	26
Peretta Packing Co. Brier Hill	0.02		x		9
Philadelphia Milk Producers Co-op. Philadelphia	0.02			Connect to Village System	18
Queens Farms Dairy Co. Copenhagen	0.02	x	x		19
Reynolds Metal Co. Massena	9.0	x		Other not determined	1
St. Lawrence Creamery Potsdam	0.05			Connect to Municipal System	9
St. Regis Paper Co. Deferiet	28.0			Immed. control of digest. liquors	23
Sealest Foods Heuvelton	0.05	x	x		3
Taylor Stone Dairy Co. Watertown	0.02			Connect to Municipal System	22
Vanity Fair Paper Mill, Inc. Gouverneur	2.42	x	x	Immed. control of digest. liquors	16
Western Condensing Co. Heuvelton	0.01			Connect to Municipal System	3



CANADA
NEW YORK
ST. LAWRENCE RIVER
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F R A N K L I N
J E F F E R S O N
L E W I S
H E R K I M E R
H A M I L T O N
O N E I D A
E S S E X
MASSENA
RAYMONDVILLE
NORWOOD
MADRID
POTSDAM
CANTON
COLTON
OGDENSBURG
HEUVELTON
GOUVERNEUR
EDWARDS
CLAYTON
CAPE VINCENT
PHILADELPHIA
NATURAL BRIDGE
DEFERIET
WEST CARTHAGE
CARTHAGE
DEXTER
BROWNVILLE
WATERTOWN
CROGHAN
BEAVER FALLS
LOWVILLE
LYONS FALLS
BOONVILLE
OLD FORGE
CRANBERRY LAKE
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NOTE:

Numbers correspond to map index numbers in Table 8

MUNICIPAL & INDUSTRIAL
WASTE TREATMENT NEEDS

BLACK-ST. LAWRENCE RIVER BASINS
(AS OF JUNE 1968)

Figure 18

TABLE 9

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs				Map Index No. (Figure 19)
		Sewers	Pri	Sec	Enlg Adv	
Adams	1,000 (900)	x	x	x		3
Albion	5,200				x	27
Barker	(520)	x	x	x		34
Brighton - Rich's Dugway	12,000				x	17
Brighton S.D.#1 & 2	23,000				x	17
Churchville	(1,000)	x	x	x		22
Elba	600		x	x		29
Fairhaven	(750)	x	x	x		9
Fairport	5,400				x	18
Gasport	650			x		33
Greece	35,000				x	21
Hannibal	(600)	x	x	x		8
Hilton	3,000			x		23
Lockport	25,100			x		38
Lyndonville	790		x	x		32
Medina	7,000			x		31
Mexico	(1,000)	x	x	x		6

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs					Map Index No. (Fig. 19)
		Sewers	Pri	Sec	Enlg	Adv	
Middleport	1,900				x		31
Newfane	2,000			x			35
Oakfield	2,200				x		27
Olcott	(1,250)	x	x	x			35
Oswego	13,000 (9,000)		x	x			7
Perinton (JC)	700				x		18
Perinton (WS)	2,000				x		18
Pittsford (T)	4,170			x			18
Pulaski	400 (2,300)	x	x	x			5
Ransomville	(950)	x	x	x			37
Red Creek	(700)	x	x	x			11
Rochester	375,000			x			19
Sackets Harbor	1,280	x	x	x			2
Sodus	(1,650)	x	x	x			12
Sodus Point	(725)	x	x	x			12
Spencerport	2,460				x		21
Webster S.D. #1	1,000				x		17
Webster S.D. #3	600				x		17

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

MUNICIPAL

Community or District	Est. Pop. Sewered or (Unsewered)	Estimated Needs Sewers	Pri	Sec	Enlg	Adv	Map Index No. (Fig. 19)
Williamson	(1,700)	x	x	x			15
Wilson	1,320			x			36
Wolcott	1,630		x	x			10

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 19)
American Kitchen	0.08	x	x	Enlarge lagoons as needed	16
Lyndon Products (same building) Ontario	0.07	x	x	" " " "	17
Ward P. Buhlmann Rose		not determined			14
Barker Chemical Corp. Somerset		not determined			15
B. W. B. Foods, Inc. Mexico	0.002	x	x	(or connect to new Municipal System)	6
Cadet Chemical Corp. Burt	0.025			Adequacy of existing settling and neutralization not determined	35

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 19)
Cowles Chemicals Co. Lockport		not determined			38
Comstock Foods, Inc. East Rochester		x	x	Enlarge lagoons as needed	18
Comstock Foods, Inc. Red Creek		x	x	" " " "	11
Cryovac Co. Lockport		not determined			38
Curtice-Burns, Inc. Alton Canning Div.					
Alton	0.27	x	x		12
Sodus		x	x		12
Dairy League Co-op. Pulaski		x	x		5
Dairymen's League Co-op. Assoc., Inc.					
Adams	0.082	x	x		4
Wolcott		x	x		10
Duffy-Mott Co.					
Hamlin	0.25			Enlarge lagoons as needed	25
Holley	0.15	x	x	Enlarge settling & neutralization facilities	26
Williamson	1.40	x	x	Enlarge lagoons as needed	16
Dynacolor Corp. Brockport		not determined			24

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs			Map Index No. (Fig. 19)
		Settling	Biolog	Other	
Empire State Pickling Co. Carlton	0.004	x	x	Enlarge lagoons as needed	28
Flintkote Co. Lockport	0.5	x	x	(or complete connection to Municipal System)	38
Food Machinery and Chemical Corp. Middleport	0.05	x		Enlarge lagoons as needed	33
Fruit Belt Preserving Co., Inc.					
Sodus Center	0.07	x	x	Enlarge lagoons as needed	6
Williamson	0.07	x	x	" " " "	17
General Electric Co. Brockport	0.26	x		Enlarge lagoons as needed; control of toxic materials	24
General Motors Corp. Harrison Radiator Div. Lockport	1.61	not determined			38
Green Dairy Farms, Inc. Wolcott	0.006	x	x		10
A. A. Grinnel Co., Inc. Elba		x	x		20
Hammermill Paper Co. Oswego	2.47	x	x		7

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs Settling	 Biolog	 Other	Map Index No. (Fig. 19)
Haxton Foods, Inc. Oakfield		x	x	Enlarge lagoons as needed	29
Hunt Wesson Foods, Inc. Albion		x	x	Enlarge chemical treatment as needed	27
Kraft Foods South Rutland	0.054			Control runoff from spray irrigation	1
Lakeshore Packing Co., Inc. Carlton	0.03	x	x		28
Lockport Canning Co. Lockport	0.072	x	x		38
Lockport Felt Co., Inc. Newfane	0.31	x	x		35
Morton Canning Co., Inc. Morton		x	x	Control of spray irrigation runoff	26
Nilok Chem., Inc. Lockport	0.05			Reduction of toxic materials; neutralization	38
Norton Labs., Inc. Lockport	0.20	x			38
Oakfield & Elba Growers, Inc. Elba		x	x		29

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

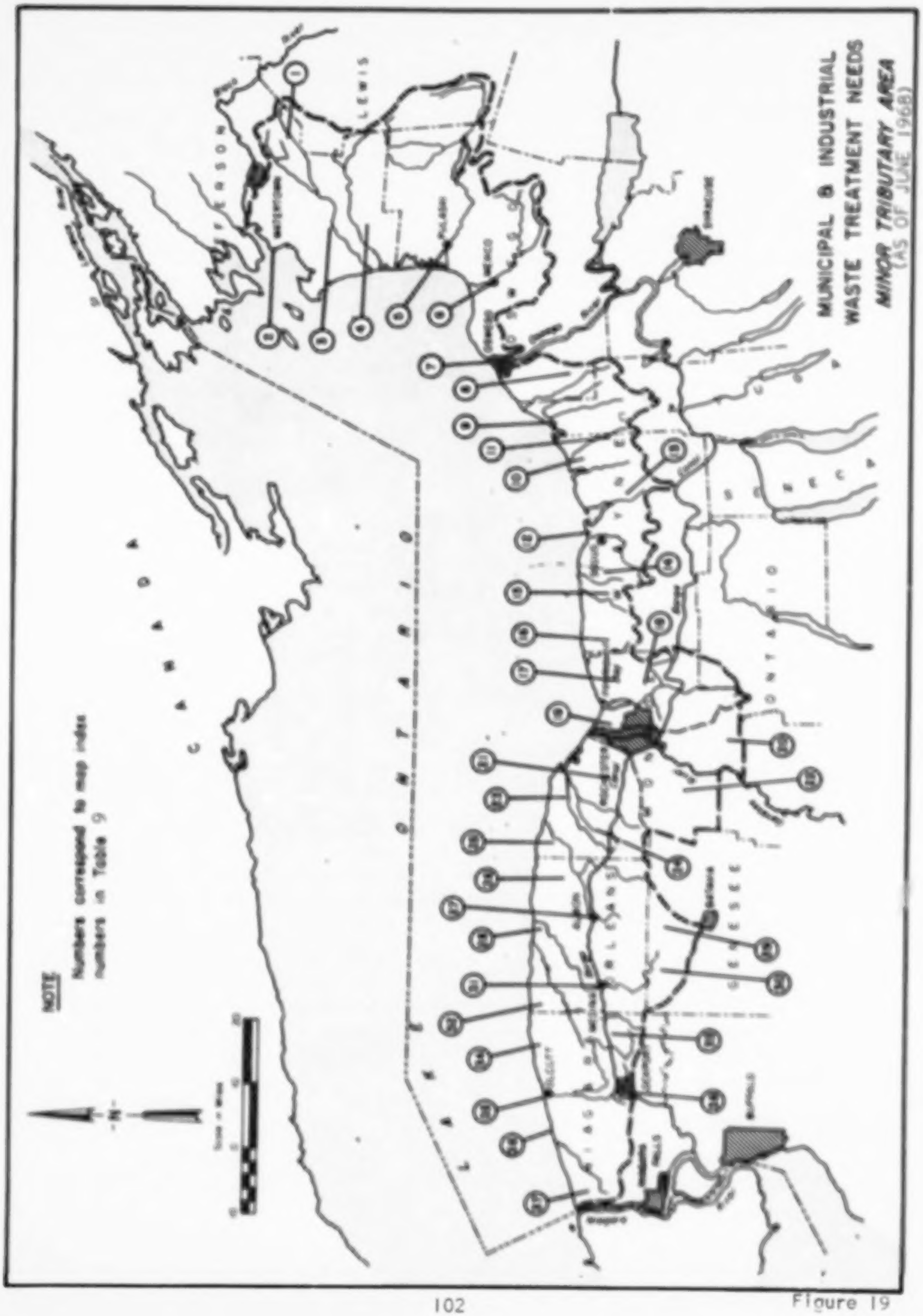
Industry Location	Waste Flow (MGD)	Estimated Needs Settling	Biolog	Other	Map Index No. (Fig. 19)
Phinney Tool & Die Co., Inc. Medina		not determined			31
Queens Farms Dairy Pierepont Manor	0.44	x	x	Enlarge lagoons & control spray irrigation	4
B. Richardson Canning Co. N. Rose		x	x		13
Salter Canning Co. N. Rose		x	x	Enlarge lagoons as needed	13
Seneca Grape Williamson	0.08	x	x	Enlarge lagoons as needed	16
Simonds Saw & Steel Co. Lockport	0.432	x		Enlarge facilities for reduction of oils & toxic metals; neutralization	38
Solvay Process Div. Wilson		x		Enlarge lagoons as needed; control toxic material	36
Southland Fine Frozen Foods Ontario Center		x	x	Enlarge lagoons as needed	16
Southland Frozen Foods, Inc. Barker	1.0			Enlarge lagoons as needed	34
Spears Company, Inc. Rose	0.02	x		Neutralization	14

TABLE 9 (Continued)

MINOR TRIBUTARY BASINS
MUNICIPAL AND INDUSTRIAL WASTE TREATMENT NEEDS
(As of June 1968)

INDUSTRIAL

Industry Location	Waste Flow (MGD)	Estimated Needs			Map Index No. (Fig. 19)
		Settling	Biolog	Other	
Wm. Stappenback, Inc. Penfield		x	x	Enlarge lagoons as needed	18
United Board & Carton Lockport	1.95	x	x		38
U. S. Gypsum Co.	0.492			Adequacy of existing bio. & settling facilities not determined	29
Upson Company Lockport	0.85	x	x		38
Van DeMark Chemicals Lockport	0.05	not determined			38
Victor Preserving Co., Inc. Ontario Center		x	x	Enlarge lagoons	16
Waco Foods Williamson	0.09	x	x		16
A. M. Wadsworth & Sons Wolcott		x	x		10
Waterman Fruit Products, Inc. Ontario Center		x	x	Enlarge lagoons as needed	16
Wayne Packing Co. Wallington		x	x		12
Whitnor Chem., Inc. Lewiston	0.05	not determined			37



MUNICIPAL & INDUSTRIAL WASTE TREATMENT NEEDS

MINOR TRIBUTARY AREA (AS OF JUNE 1968)

NOTE
Numbers correspond to map index numbers in Table 9
N
Scale in Miles
C A N A D A
L A K E O N T A R I O
JEFFERSON
LEWIS
OSWEGO
WAYNE
SENECA
ONTARIO
MONROE
ORLEANS
GENESEE
NIAGARA
WATERTOWN
PULASKI
OSWEGO
SYRACUSE
ROCHESTER
BATAVIA
LOCKPORT
BUFFALO
NIAGARA FALLS

Figure 19

Advanced Waste Treatment

For many stream sectors in the Basin, secondary treatment will not assure acceptable quality. Additional pollution control needs for these sectors will usually involve either advanced waste treatment or streamflow augmentation, or both. Preliminary evaluation by the New York State Department of Health (NYSDH) and FWPCA of the capacities of streams to assimilate waste during critical periods of low flow and high temperature have indicated there are 20 municipalities and industries that may be required to consider advanced waste treatment. In other words, their effluent organic loading to a stream after secondary treatment may still exceed the stream's assimilation capacity. The more significant communities and industries at which this situation occurs, or is expected to occur, are: the Eastman Kodak Company, Georgia Pacific Paper Company, the proposed Meadowbrook Limestone S.D., Newton Falls Paper Company, the Gates-Chili-Ogden S.D., the Cities of Auburn and Oneida, and the Village of Skaneateles.

Nutrient Control

Of the nutrients which support biological growth, nitrogen and phosphorus are considered most significant. Of the two, phosphorus can be more effectively controlled. Major efforts must be directed toward initiating removal of phosphates from municipal and industrial wastewaters which carry large quantities of nutrients to the lakes and streams of the Lake Ontario Basin. Land runoff, which includes agricultural drainage, is the other major contributor and efforts must be directed toward controlling this source as well.

Processes and techniques for the removal of phosphate from municipal wastewater are today a reality and can be applied at modest cost. It has already been demonstrated that chemical treatment will reliably remove 85 to 90 percent of the total phosphate present in municipal wastewater. Side benefits are also achieved through a substantial reduction of other pollutants. Although not all industrial wastewaters are amenable to the present treatment methods, slight alterations of their effluent discharge or improved plant housekeeping methods can usually achieve the same end.

Proposed treatment methods include cold lime and alum chemical treatments, which are reliable and easily controlled. Chemical treatment can be integrated with conventional biological treatment at either the primary sedimentation stage or the activated sludge stage. Potential net costs of approximately 5 cents per 1,000 gallons are currently attainable.

Flow Regulation

Regulation of lake and artificial impoundment releases to effect continuous streamflows adequate for maintaining water quality consistent with downstream uses is a feasible solution to many of the water quality problems in the Lake Ontario Basin. It must be understood, however, that before augmentation of streamflows can be considered both secondary treatment, in terms of organic reduction, and treatment for reduction of nutrients, must be accomplished. At present there are a number of streams for which dilution of wastes is taken into consideration when determining releases of upstream storage. For nearly all these sectors under regulation, which number about 20, the general viewpoint is held that streamflows are inadequate for water quality control. In reality most pollution problems exist below these sectors because of an over-dependence on dilution of wastes rather than on providing adequate treatment of wastes before discharge.

Determinations of streamflow requirements, made jointly by NYSDH and FWPCA for present and projected loading conditions on stream sectors in the Basin, were calculated assuming that a minimum of 85 percent BOD removal is achieved before 1985 and 90 percent or better thereafter. Only 12 sectors were determined to require low flow augmentation when present waste inputs are treated adequately; in 1985 fifteen sectors will need augmentation; and by 2020 eighteen sectors will need augmentation. Those with significant requirements are shown in Table 10. Detailed information including gross and net streamflow requirements are presented in the subbasin reports for the Basin. (1), (2), (3) and (4)

There are many sectors which are projected to experience only marginal, or even less than acceptable, quality, if the present pattern of storage releases continues and if the projected loadings materialize. These sectors are mainly on the outlet streams of the Finger Lakes. The Cities of Syracuse, Auburn and Canandaigua, the New York State Department of Public Works, the Oswego River Watershed Corporation and other regulating interests should provide releases to enhance the quality of these streams while still maintaining lake levels sufficient for other legitimate uses such as water supply, recreation, and power.

Control of streamflows for peak power purposes should not be practiced to the extent that sufficient dilution of downstream wastes is not provided. Niagara Mohawk's regulation of the Raquette River, the Oswego River Watershed Corporation's control of the Seneca and Oswego Rivers, Rochester Gas and Electric's and New York Department of Public Works' joint control of the Genesee River, and New York Electric and Gas (also in cooperation with the NYDPW) control of the Upper Seneca River are examples of situations where the pattern of operation should be altered to improve downstream water quality.

The diversions from the Barge Canal System are critically important to the quality condition of many of the small tributaries in the Lake Ontario plains area and should be continued at least at the present levels. As future re-evaluations of the present canal uses show possible reassignments of priority to the canal water,

TABLE 10

LOW FLOW AUGMENTATION NEEDS IN LAKE ONTARIO BASIN*

Stream and Sector	Comments
Genesee River City of Rochester and Eastman Kodak Co.	Kodak constructing plant capable of about 90 percent BOD removal. Augmentation still appears necessary in immediate future unless other improvement measures are taken. Additional releases are possible from Barge Canal or from proposed Corps of Engineers reservoir.
Genesee River Gates-Chili-Ogden Sanitary District	Coordinated study of sewerage needs in Monroe County shows a possible future loading to the river of 10 times the present, in which case the existing flow in the river would be insufficient.
Black River Lyons Falls and Georgia Pacific Paper	Present releases by the Black River Regulating Board are expected to provide only marginal quality after Georgia Pacific installs secondary treatment. Additional releases will be necessary if projected loadings materialize and other improvement measures are not undertaken.
Limestone Creek Proposed Limestone-Meadowbrook-Manlius S.D. Treatment Plant	Additional streamflows will be required below this discharge if the anticipated high rate of growth materializes east of Syracuse. The Corps of Engineers has under consideration an upstream reservoir which could provide this augmentation.
Eighteenmile Creek Lockport and Area Industries	Diversions from the Barge Canal must be continued at their present rate of better than 50 cfs for minimum water quality. Utilization of the full authorized diversion of 100 cfs or more should be obtained for enhancement of quality.

*Refer to individual subbasin reports for actual streamflow requirements and the basic assumptions used in each determination.

additional diversions should be considered to upgrade and enhance the quality of these small streams. Irondequoit, Allens and Eighteenmile Creeks are most dependent on canal diversions (after the Genesee River) and these creeks should receive particular attention.

Combined Sewers

Control of discharges from combined sewers must be given serious consideration throughout the Basin, particularly in the case of the older and larger cities of Buffalo, Rochester, Syracuse, Niagara Falls, and Watertown. In many of the newer and smaller urban areas partial or complete separation of sewers has been effected.

Until economically feasible methods of solving the problems are developed, existing combined sewer systems should be properly maintained. Adequate provision should be made for continuous cleaning and repair of interceptors and relief chambers, especially in the Syracuse and Rochester systems, which have a total of over 100 possible overflow points to Onondaga Lake (via two tributaries) and the Lower Genesee River. Overflow regulating devices should be adjusted to convey the maximum practicable amount of combined flows to and through waste treatment facilities. In the case of newly developed urban areas only separate sewer systems should be allowed, unless provision is made for retention and treatment of combined flows.

The Cities of Rochester and Syracuse have undertaken engineering studies focussing on necessary remedial measures to control discharges from their respective systems. In addition, the City of Syracuse has improved the condition of its main interceptors to correct the unwarranted situation reported by consulting engineers in 1961, that about 20 overflow devices, designed to operate only during storms, were discharging continuously.

The Federal Government has recognized the need for solutions to the problems by overflows from combined sewer systems and is currently conducting extensive research studies on new and economic methods of control. The Water Quality Act of 1965 established a four-year program of grants and contract authority to demonstrate new or improved methods to eradicate the problem of combined sewers.

Federal Installations

Of the approximately 150 Federal installations in the Lake Ontario Basin only a small percentage discharge directly to surface or sub-surface waters. The most significant facilities of this type and recommended treatment needs for each are shown in Table II. Plans have been drawn up and in many cases already approved for the needed improvements at all of the installations shown in this table.

TABLE II

FEDERAL INSTALLATIONS WASTE TREATMENT NEEDS

Installation	Needs
Thousand Island Camp Annex-USAF Alexandria Bay	Disinfection.
Watertown Air Force Station-USAF Watertown	Tertiary treatment lagoon.
Hancock Field-USAF North Syracuse	Some wastewater discharge not yet connected to Onondaga County municipal sewerage system.
Camp Drum-U.S. Army Jefferson County	Expansion to secondary treatment.
Naval Research Lab.-U.S. Navy Dresden	Secondary treatment required.
Alexandria Bay Coast Guard Sta. Alexandria Bay	Primary and secondary treatment.
Oswego Coast Guard Station Oswego	Connect to City of Oswego municipal sewerage facilities.
Veterans Administration Hospital Canandaigua	Expansion to secondary treatment.
Snell Lock-St. Lawrence Seaway Development Corp. Massena	Secondary treatment needed for tourist facilities. Holding tanks and dockside collection needed for all vessels.
U. S. Post Office Moravia	Connect to Village of Moravia municipal sewerage facilities.
Air Force Plant 49 Buffalo	Connect all waste to municipal sewerage system.
Niagara Falls Municipal Airport Niagara Falls	Connect to City of Niagara Falls municipal sewerage system.
Nuclear Materials & Equipment Corp.-AEC Model City	Expansion to secondary treatment.

Research and Development

In spite of stepped-up efforts in recent years on the part of both public and private research, there are serious gaps in scientific knowledge and technology which are hampering a satisfactory attack on complex problems related to water pollution. Control measures and construction now in progress consist primarily of application of known technology with minimum delay. These have the immediate objectives of correcting obvious pollution problems long neglected, and to achieve maximum restoration of water quality in the shortest practicable time. A comparison of the abatement measures under on-going programs with the improvement needs, detailed above in this Chapter, required for achieving and maintaining planned water quality reveals that a substantial amount of mission-oriented research and development is urgently needed.

The major problem conditions in the Lake Ontario and United States St. Lawrence River Basins which require research designed to find and develop feasible technology are: 1) eutrophication, 2) pollution by organic residues in secondary effluents, 3) pollution by problem constituents in industrial wastes, 4) pollution from combined sewers, 5) pollution resulting from agricultural activities, 6) temperature increases due to waste heat discharges, 7) ultimate disposal of residues, 8) sedimentation, and 9) inadequate techniques for measuring water quality.

Specific items of research and development activity that could yield valuable information and new techniques for direct application to problems in the Basins are listed:

1. Investigation of phosphate sources and budgets on one or more prototype watersheds, with special emphasis on determining yield factors suitable for application to larger watersheds.

2. Research on mechanisms and processes related to eutrophication in both shallow and deep lakes.

3. Development of techniques, utilizing mathematical models, for predicting restoration of lake quality under assumed modifications of inputs.

4. Research of agricultural practices on a prototype watershed to determine methods for controlling pollution by fertilizer and pesticide residues.

5. Plant-scale installations at one or more sewage treatment plants to demonstrate the efficacy of phosphorus removal by chemical and biological-chemical techniques.

6. Field research at one or more outfalls discharging spent cooling water in lakes to determine the fate and effects of such discharges on the aquatic environment.

7. Investigations of dilution, dispersion and movement of pollutants in inshore waters of Lake Ontario, including determination of the effects of shoreline configurations.

8. Research to find permanent solutions for problems associated with combined sewer systems.

9. Research and demonstration of improvements in land management practices to minimize soil erosion and pollution by sediments.

10. Development of improved and simplified techniques for laboratory analyses of chemical constituents.

11. Development and standardization of a faster, improved analytical method for determining the oxygen demand of organic waste material.

12. Development of improved analytical methods for determining bacterial quality and evaluating whether compliance with official standards is being achieved.

Chapter 5

COSTS AND BENEFITS

Cost of Waste Treatment

The cost of providing adequate treatment for municipal and industrial wastes presently being discharged to the surface waters of the Lake Ontario Basin is estimated to be over $300 million. This figure excludes the industrial treatment costs for the Niagara River Basin, and the cost of nutrient control which should be an integral part of all treatment facilities in the Basin. The City of Rochester recently completed plans for expansion of its facilities which will provide a high reduction of phosphates.

Estimates of municipal treatment costs were based on the assumption that conventional secondary treatment, required by recent New York State regulations for treatment plant design, would achieve at least 85 percent BOD removal. Costs of treating industrial wastes were estimated by two methods. The first involved equating industrial loading when predominantly organic in nature to an equivalent domestic waste; the second assumed that waste treatment included only non-biological processes and that settling facilities were the major need.

Municipal Waste Treatment

Approximately $187 million is estimated as the cost of providing the minimal requirements of treatment for municipal wastes in the Basin. This is the aggregate cost of providing primary and secondary treatment where no treatment now exists (130 communities), for upgrading the existing primary type plants to secondary and expansion of some existing secondary plants (88 communities). As shown in Table 12 about four-fifths of the total cost is for upgrading primary plants to secondary. Four of the largest municipalities (Rochester, Buffalo, Syracuse and Niagara Falls) account for $105 million of the total $154 million estimated. The City of Rochester is at present the only one of these four large municipalities committed to a definite expenditure, that being about $35 million for treatment and another $13 million for a three-mile long outfall into Lake Ontario.

The 130 communities that need completely new facilities are mostly smaller population centers of less than 2,500. Many of these are also unsewered. The per capita cost for many of these communities is estimated to be relatively high and, as a result, the total cost of constructing these plants is about one-fifth the cost of expanding existing primary plants despite the fact that their population served is less than 15 percent of the latter.

Advanced waste treatment for high organic removal has been estimated at about $3.8 million, utilizing chemical coagulation. There are about 11 communities which, from a preliminary survey, appear to require high reductions of organic material to assure acceptable downstream quality. Most of these needs are for communities in the Genesee and Finger Lakes Basins.

TABLE 12

ESTIMATED COST OF MUNICIPAL WASTE TREATMENT 1/
LAKE ONTARIO BASIN

Treatment Needs	Estimated Cost	
Primary and secondary	$ 29,200,000	
Upgrading to secondary and enlargement of secondary facilities	154,000,000	2/
Advanced treatment (high organic reduction)	3,800,000	3/
Total	$187,000,000	

1/ Includes the needs of all communities with populations greater than 500.

2/ Includes plans by the City of Rochester to spend approximately $48 million for addition of secondary facilities and new outfalls into Lake Ontario.

3/ Based on cost of adding facilities for chemical coagulation.

Industrial Waste Treatment

The estimated total cost of providing the equivalent of secondary treatment by the 200 industries known to have discharges to the Basin streams and lakes is about $122 million. This does not include the cost of treatment by the 20 to 30 industries on the Niagara River and its tributaries. Most of these industries are in the process of studying their treatment needs in compliance with State abatement schedules. Any estimate of the treatment costs is extremely difficult until the exact nature of the needs is known, especially since most of these industries produce "hard type" wastes that are peculiar to each operation and for which the treatment requirements are likewise different for each operation.

Table 13 presents a breakdown of the cost of industrial waste treatment into biological and non-biological. Nearly 78 percent of this total or $95 million is required for reduction of organic material in industrial wastewater. More than 80 percent of this is the estimated expenditure required by pulp and paper mills and food processors. There are 21 manufacturers of paper products in the Basin, only one of which effects actual waste treatment; many effect in-plant reductions as a result of attempts to capture fibers from white waters. An estimated 100 food processors, scattered throughout the Basin, require about $45 million worth of new or improved treatment facilities.

TABLE 13

ESTIMATED COST OF INDUSTRIAL WASTE TREATMENT 1/
LAKE ONTARIO BASIN

Treatment Needs	Estimated Cost
Settling and biological treatment facilities	$ 95,000,000
Non-biological treatment - neutralization, precipitation, etc.	19,000,000
Advanced treatment for high organic reduction	8,000,000
Total	$122,000,000 2/

1/ Estimate based on assumption that each industry presently discharging separately will construct self-owned and self-operated treatment facilities.

2/ The total cost shown does not include industries on the Niagara River. These cost estimates were not available due to the uncertainty of the treatment needs of the more than 20 large industries in the area.

Phosphate Control

Table 14 contains a summary of the total cost of accomplishing significant phosphate reductions through treatment of municipal and industrial waste. As shown, about $120 million would be required throughout the Basin. As noted in Table 14 the cost is based on constructing facilities in addition to those needed for secondary treatment. Methods of phosphate treatment currently under development, and for which great success has been achieved to date, include techniques utilizing existing secondary units. Application of these techniques would undoubtedly reduce considerably the figures shown in Table 14.

TABLE 14

ESTIMATED COST OF MUNICIPAL AND INDUSTRIAL
WASTE TREATMENT FOR PHOSPHATE REDUCTION
LAKE ONTARIO BASIN

Type	Cost
Municipal	$ 78,000,000
Industrial	42,000,000 1/
Total	$120,000,000

1/ Does not include industries on the Niagara River.

Benefits

Water quality control benefits are those net contributions to public health, safety, economy and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of a change in water quality. The net contribution may be evaluated in terms of avoidance of adverse effects which would otherwise accrue in absence of water quality control. (12)

Numerous examples may be cited where benefits will be lost in the Lake Ontario Basin because of undesirable water quality. Major areas where recreational activities are impaired by poor water quality include Onondaga Lake, Oneida Lake, Lake Ontario at Rochester, the Barge Canal at Waterloo and Seneca Falls, Cayuga Lake at Ithaca, Seneca Lake at Geneva, the upper Niagara River, the lower Genesee River and the Oswego River. The problems at these locations and many more areas are caused mostly by one or a combination of: excessive coliform counts from inadequately treated sewage or industrial waste; fouling of the surface of waters with oil, scum and other harmful and unesthetic floating debris; masses of decaying weed and algal growths piled on shorelines; combined sewer overflows; vessel and watercraft wastes; and drainage from agricultural lands.

Onondaga Lake is a classic example of a lake stripped of its recreational potential. Swimming and water skiing are obviously unthought of; boating is highly undesirable; fishing is limited to pollution-tolerant carp. The unusable condition of Onondaga Lake is made even more unfortunate by the fact that along its entire north and eastern shoreline is a vast park where the facilities for enjoying these activities can easily be located.

The Bureau of Outdoor Recreation estimates that if Onondaga Lake were suitable for water contact activities, its total accumulative attendance in recreation days over the 35-year period 1965-2000 would approach 95,000,000.

The Niagara River receives heavy traffic from all types of commercial and pleasure craft. However, an excursion on the river necessitates removal of an unsightly oil ring from boat and motor.

There are four public beaches located near the Rochester Metropolitan area of Lake Ontario. Unfortunately, three of the four beaches were closed during 1967 due to pollution, eliminating a source of swimming recreation for almost 750,000 people. These beaches had an average visitation of 1,700,000 in previous years.

Another example is presented by the Bureau of Outdoor Recreation to show the tangible loss to recreation from poor water quality. The Bureau developed an analysis (see Table 15) showing that visitation to the Basin's public beaches would have increased 62 percent over the present use if all the public beach waters were suitable for swimming.

Besides the recreational impairment which is experienced in the Basin, use of some surface waters for drinking and other domestic uses has been greatly curtailed. Water from the Niagara River will quite often have an objectionable taste because of the high phenol content. Poor drinking water also exists in other areas because of tastes imparted by algae or from excessive chlorination dictated by bacterial contamination.

Large expenditures of industrial funds are made annually on raw water treatment to prevent adverse effects on products and equipment. Allied Chemical Corporation spends one-half million dollars a year conditioning Onondaga Lake's polluted waters. On the other hand, industrial discharges containing dyes and other various compounds color the waters of many area streams.

TABLE 15

INFLUENCE OF WATER QUALITY ON SWIMMING AT PUBLIC BEACHES IN THE LAKE ONTARIO BASIN, 1965*

(Estimated activity occasions)

1. Attendance at public beaches exhibiting poor water quality	1,160,000
2. Attendance at public beaches not exhibiting poor water quality	2,519,000
3. Total estimated visitation at the Basin's public beaches	3,679,000
4. Increase in attendance with improved water quality	2,261,000
a. reopening of closed beaches	33,000
b. increased participation by present patrons	589,000
c. increased attendance of present nonpatrons	1,639,000
5. Annual loss without improved water quality conditions and with enforcement.**	3,421,000
6. Estimated total swimming visitation with improved water quality***	5,940,000

* Table taken from U. S. Bureau of Outdoor Recreation Report (6)
** Total of 1 and 4
*** Total of 2 and 5

It is difficult to place an exact figure on the many tangible and intangible benefits that would result from an improvement of Basin waters. The Bureau of Outdoor Recreation estimated that $273 million was spent in 1960 on recreational travel within the Lake Ontario Basin. This figure represents in a small way the magnitude of the overall benefits that could be derived through an enhancement of recreational opportunity by improved water quality. Equally significant are the benefits which may be derived from the other water-dependent uses such as lower treatment costs for domestic and industrial water supply and an improved lake fishery, which in turn would generate large volumes of retail business for boat liveries, tackle shops, groceries, service stations and motels. The most important benefit does not lend itself to monetary evaluation but certainly provides the impetus necessary to offset all costs; that is the safeguarding of public health and welfare.

CHAPTER 6

CONCLUSIONS

1. Problems directly caused by or related to water pollution have been identified in Lake Ontario and the United States waters tributary to the Lake; the Niagara River and its United States tributaries; and the International section of the St. Lawrence River and its United States tributaries.

2. Many valuable water uses are being impaired to varying degrees by a variety of pollutants. The principal sources of this material include wastes from municipalities, industries, combined sewer overflows, agriculture, urban runoff and watercraft.

3. Eutrophication is a grave and serious problem, particularly in Lake Ontario and Oneida Lake. Nutrient-rich waters in these and other lakes support massive growths of biota, especially *Cladophora*, which cause intolerable conditions in recreational waters, serious loss of esthetic values, and severe impairments in water supplies. Pile-up of *Cladophora* along the entire United States shoreline occurs every growing season.

4. Present knowledge and understanding of both the contributing causes and the complex processes of eutrophication indicate that the most beneficial and feasible remedy is deliberate reduction, to the maximum extent possible, of all identifiable phosphorus inputs to streams and lakes.

5. Discharges of inadequately treated organic wastes by communities and industries are causing undesirable depletion of the dissolved oxygen essential for a healthy, balanced, aquatic life environment in lakes and streams. Serious depletion occurs in the Lower Genesee River, Oatka Creek, Honeoye Creek, Barge Canal (vicinity of Newark), Upper Seneca River, Owasco Outlet, Skaneateles Creek, Black River and Onondaga Lake. Moderate to serious depletions occur in Eighteenmile Creek, Tonawanda Creek, Upper Genesee River, Irondequoit Creek, Keuka Outlet, Canandaigua Outlet, Ninemile Creek, Lower Seneca River, Oswego River (Fulton), Oneida Creek, Oswegatchie River, Grass River and Raquette River.

6. The discharge by industries of significant amounts of suspended solids, chemical residues, and other deleterious waste constituents is causing high turbidities, severe discoloration, bottom deposits, rafts of foam and debris, and other manifestations of degradation. Particularly notable are conditions occurring in the Upper Niagara River, Eighteenmile Creek, Oatka Creek, Upper Seneca River, Oswego River, Onondaga Lake, Black River, Grass River and St. Lawrence River.

7. Bacterial pollution attributable to wastes from municipalities, including their combined sewer overflows, which are not receiving adequate treatment and disinfection, is a continuing health hazard in swimming areas and municipal water intake locations. Bacterial counts in the Niagara River frequently violate established standards. Beaches on Lake Ontario in the Rochester area, on Seneca Lake at Geneva, and on Cayuga Lake at Ithaca are presently closed due to bacterial contamination.

8. Two nuclear power plants are now under construction on the south shore of Lake Ontario. One of these will be in operation by the end of FY 1969. Planning is under way for another plant, to be located on Cayuga Lake, scheduled to start up in FY 1973. The probable effects of these facilities on the Lake environments, particularly that of heat and radionuclide discharges, are not satisfactorily understood or predictable. Further investigation is needed to provide information for properly assessing the impact of such operations.

9. Oil discharges, which cause damage to water uses, aquatic life and occasionally result in damage by burning, frequently occur in the Buffalo-Niagara area. Certain industrial operations in other areas, commercial ships, and oil terminal operations represent continuing potential sources of oil pollution which can despoil beaches and other recreational areas, cause taste and odors in water supplies, be toxic to fish, and destroy wildfowl.

10. Vessels of all types, commercial and recreational, are contributors of both untreated and inadequately treated wastes in open waters, local harbors and inland waterways. This causes significant loss in esthetic quality, and constitutes a continuing threat to safe bacterial quality in the vicinity of water intakes and swimming areas.

11. Pesticide pollution in lakes and streams results from the application of these materials by spraying and dusting. Heavy usage occurs in the extensive fruit growing belt in the Lake Ontario plain area, and in numerous upland areas under intensive cultivation. An example of the latter is the use of organic phosphates and other compounds by potato growers which has resulted in numerous fish kills on both East Koy and Wiscoy Creeks in the Genesee River Basin. Considering the present limited knowledge of the fate and harmful effects of pesticides once they are released, and the ever-increasing use of the materials, it is vitally important that appropriate measures be taken to positively prevent ecological disasters, and even threats to human safety through contamination in food sources and water supplies.

12. The most significant physical characteristics and processes in Lake Ontario that relate to dispersal, transportation and effects of pollutants are: 1) the large volume of water mass per unit area which tends to maintain high oxygen and nutrient levels in the hypolimnion, 2) circulation patterns which move nutrients and other pollutants

freely in many directions while at the same time substantially decreasing the flowing-through time of large volumes of water, 3) the discharge of the Niagara River which is by far the greatest hydrological factor affecting the Lake environment, and 4) the development of a thermal bar which not only limits the dispersal of pollutants but may function as a mechanism whereby nutrients are concentrated and held in the inshore growing area at the beginning of the *Cladophora* growing season.

13. Many of the pollution problems cited in this report will be substantially corrected by 1972 as a result of actions now in progress, or contemplated, under the Pure Waters Program of the State of New York. This program deserves commendation and support from all sectors, public and private. Administered by the State Health Department, the program has most of the essential tools and resources necessary for cleaning up waters in the State.

Chapter 7

RECOMMENDATIONS

Immediate and long-range pollution control measures are recommended for meeting the present and future water quality requirements in the Lake Ontario and United States St. Lawrence River Basins. Immediate needs are those improvement measures which should be in effect no later than July 1972, unless otherwise indicated, to eliminate gross pollution and otherwise achieve a large measure of quality restoration by the application of presently known technology. The long-range needs are defined as those measures which should be planned and implemented to the degree practicable today, but which generally need more research and time to accomplish. In many cases the long-range needs are nothing more than an expansion or continuation of the immediate needs. Also included are research needs pertinent to problems in the Basins.

The New York State Department of Health (NYSDH) and FWPCA jointly concur in the recommendations that follow; in a few cases, qualifying statements by NYSDH are given in brackets.

Immediate Needs

1. *Municipal Waste Treatment* - All municipal waste treatment facilities should be designed and operated to provide secondary (biological) treatment and to achieve at least 85 percent reduction of untreated BOD. The communities affected by this recommendation and the required improvements for each are listed in Chapter 4.

[*While NYSDH defines secondary treatment to mean 75-95 percent reduction of BOD and suspended solids, it is encouraging designs to achieve at least 85 percent reductions.*]

2. *Industrial Waste Treatment* - All separately discharging industries should provide the equivalent of secondary treatment for all oxygen consuming wastes unless additional treatment is required to meet stream standards. Other wastes contributing to pollution should be treated, modified or excluded from discharging as necessary for compliance with stream standards. Industries affected and the required improvements for each are listed in Chapter 4.

3. *Municipally-Treated Industrial Waste* - Discharge of treatable industrial wastes (following needed pretreatment) to municipal sewer systems should be encouraged. However, the effluent from such a plant must compare favorably with effluents from plants receiving only domestic wastes.

4. *Advanced Waste Treatment* - Where secondary treatment is not adequate for meeting stream quality standards based on expected streamflows, additional facilities for achieving further reduction in waste loadings or additional streamflows should be provided. Locations requiring such consideration have been identified and are described in Chapter 4.

5. *Phosphate Reduction* - Effective immediately all plans for new municipal treatment plants including enlargement or upgrading of existing plants, should incorporate provisions for removal on a continuous basis of not less than 80 percent of the total phosphorus in the influent sewage. As of July 1972 all municipal waste treatment facilities serving an equivalent population (PE, BOD basis) of 5,000 or more should have facilities in operation removing not less than 80 percent of the input phosphorus. As of July 1978 all municipal waste treatment plants should be removing not less than 90 percent of input phosphorus.

All industries with significant amounts of phosphorus in waste discharged through private outfalls should have facilities for the maximum practicable removal of phosphorus in operation by July 1972.

[*NYSDH does not fully concur in this recommendation, and is currently working on a phosphate reduction policy.*]

6. *Disinfection* - Facilities should be provided for disinfection of all waste treatment plant effluents containing potentially harmful bacteria. These facilities should be operated to achieve effective disinfection on a year-round basis at all locations except where it is conclusively determined that no hazard will exist if operated for only part of the year.

7. *Temporary Industrial Pollution Control Measures* - Temporary measures should be taken to control gross industrial pollution until permanent treatment facilities are designed and constructed.

8. *Control of Lakeshore Discharges* - The inland lakes, especially the Finger Lakes and Oneida Lake, should be adequately protected against seepage and direct sewage discharges from lakeshore cottages and campsites.

9. *Federal and State Installations* - Federal and State installations needing new or expanded treatment facilities should budget the necessary funds and proceed with construction without delay. Federal and State installations should provide treatment for their wastes equal to or better than that which would be required of municipalities or industries producing similar wastes.

10. *Streamflow Regulation* - Regulation of streamflows to provide additional dilution water for water quality control should be considered for many sectors in the Basins. Multi-purpose projects which are approved, funded and scheduled for construction should include storage for water quality control whenever social or monetary benefits justify such practice.

11. *Combined Sewer Systems* - Combined sewers should be prohibited in all newly developed areas and separated in coordination with all urban reconstruction projects, except where other techniques can be applied to control storm water pollution. Overflow regulating devices of combined sewer systems should be revised where necessary and operated in such manner as to convey the maximum practicable amount of combined flow to treatment facilities.

12. *Pollution by Agriculture* - Agricultural practices should be improved to attain maximum protection of waters in the Basins against fertilizer residues, manures, pesticides and soil erosion material. Organization and adequate funding of Soil Conservation Districts should be encouraged.

13. *Pesticide Control* - Accurate reporting on disposition of pesticide purchases should be instituted and maintained, including establishment of accountability for application of pesticides, monitoring of concentrations in the aquatic environment, and institution of corrective measures where needed.

14. *Waste Heat* - The discharge of waste heat should be so controlled that recognized water uses are not adversely affected.

15. *Radioactive Material* - Discharges from facilities using radioactive materials should be so controlled as to protect the environment against harm from these or any resulting byproduct.

16. *Oil and Other Hazardous Material* - The direct discharge of oil from any source into any waters of the Basins should be stopped. An inventory should be compiled of all sites where potential exists for major spills of oil and other hazardous materials. Measures to prevent the possible entrance of these materials into the waters as a result of spills should be encouraged. An alerting system should be developed and operated for dealing with accidental spills of oil and other hazardous materials.

17. *Dredging Disposal* - Polluted dredging materials should not be disposed of in Lake Ontario, inland lakes or other waters of the Basins.

18. *Stream Regulating Works* - Operating practices at navigation and hydroelectric power facilities should be revised where these practices presently impair other stream uses such as recreation, fish

life, and esthetic enjoyment. Hydroelectric plants should be required to release flows at least equal to the 7-day once-in-10-year low natural streamflow at all times when the inflow to a reservoir is greater than that rate--and to pass without reduction all inflow at lesser rates. Whenever a change in a power license is contemplated by the Federal Power Commission, the need for additional regulation of streamflow for water quality control should be investigated and such regulation provided where feasible.

19. *Prevention of Bypassing at Treatment Plants* - Standby equipment and contingency plans for emergencies should be provided at municipal and industrial treatment facilities to minimize the probability of discharging inadequately treated effluents because of maintenance work, plant revisions, or accidents.

20. *Elimination of Streambank Dumps* - Improper and indiscriminate dumping of garbage, trash, rubbish and other deleterious refuse along the shores of lakes and the banks of watercourses in the Basin should be prohibited.

21. *Surveillance of Recreation Waters* - Surveillance of all recognized bathing waters and other recreation waters should be conducted by the appropriate Health Department offices on a routine basis. Samples should be collected and analyzed for both total and fecal coliforms, with frequency appropriate to the usage.

22. *Boat and Vessel Pollution* - Control of pollution from commercial and pleasure craft to Lake Ontario, the St. Lawrence River, inland lakes and other navigable waters should be given high priority by the appropriate local, State and Federal agencies. This includes the proper handling and disposal of these wastes on shore.

Long-Range Needs

1. *Future Waste Treatment Needs* - By the year 1985 all municipal and industrial waste treatment facilities should be achieving an overall reduction in BOD of 90 percent or better, with comparable reductions in suspended solids and in dissolved solids, especially the nutrients. Industrial waste control should be so conducted as to anticipate and prevent problems that would otherwise result from the continuing development of new products and their associated wastes.

2. *Master Planning* - The results of the present comprehensive studies and reports for collection, treatment and disposal of sewage should be carried out. This would include phasing out the conglomeration of small inefficient treatment facilities and treating the combined wastes in larger and more efficient facilities.

3. *Upgrading of Stream Classification* - The present State program of reviewing existing stream classifications looking to the upgrading of the waters should be actively pursued.

4. *Water Quality Monitoring* - The cooperative local-State-Federal water quality monitoring programs should be expanded as needed throughout the Basins.

5. *Elimination of Septic Tanks* - The use of septic tanks systems in urban areas should be discontinued in favor of municipal collection systems. Septic tanks should be used only in estate developments and rural areas where satisfactory soil conditions exist.

6. *Lakeshore Discharges* - Collection systems and treatment facilities should be provided for all developed shoreline areas where financially feasible; otherwise approved treatment and subsurface disposal of effluent should be provided.

Research Needs

1. *Land Management Demonstration Project* - The Soil Conservation Service of the U. S. Department of Agriculture, in cooperation with other Federal, State and local agencies, should undertake an intensive study of the causes contributing to the siltation and turbidity problems of lakes and streams. A model subwatershed, such as the Honeoye Creek watershed where soil erosion is known to be extensive, should be selected and subjected to an in-depth investigation with the objective of demonstrating proper land management practices that can be applied throughout the Basin to effectively reduce pollutional material in runoff.

2. *Eutrophication* - Research is needed in the areas of: methods of controlling over-production of algae; techniques for restoring eutrophic lakes; and more effective and less costly methods for removing dissolved solids, especially those leading to eutrophication of lakes, from wastewaters.

3. *Criteria Research* - Coordinated Federal and State investigations should be made to refine and correlate the water quality criteria pertinent to each water use. Areas needing further research should be made known to universities and others engaged in fish toxicity and other types of tolerance testing. Special attention should be given to new studies focussing on bacterial criteria for recreational water uses and their relationship to the health of the swimmers.

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